New Scientist

WEEKLY 21 January 2023

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And what that means for how we treat it

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Virtual event

Secrets of the Large Hadron Collider

Join particle physicist Clara Nellist, part of the ATLAS experiment at the LHC, for a deep dive into the past, present and future of the largest particle collider ever built. Find out how the LHC expands our knowledge of the universe, and learn what it is like to work on one of the world's greatest physics experiments. Catch it on 7 February at 6pm GMT/ 1pm EST. Tickets cost £14.

newscientist.com/events

Tour

Norway: Wonders of the Arctic

Explore Norway's beautiful fjords and discover the frozen Svalbard archipelago by land, sea and air, all with a chance of glimpsing whales, polar bears and the northern lights. Led by Rowan Hooper, podcast editor at *New Scientist*, the nine-day tour starts on 2 March and costs £5549.

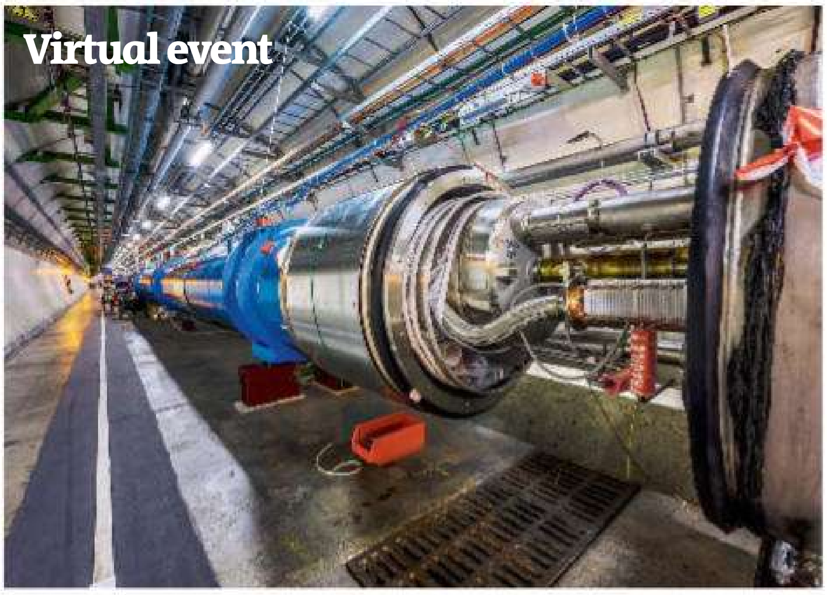
newscientist.com/tours

Podcast

Weekly

The podcast team discusses news that an AI will advise a defendant during a US court case next month. There are also two bonus episodes. In the first, writer David Finnigan and Cassie Lynch, a descendant of the Noongar people of Australia, discuss stories that are thousands of years old. In the second, the podcast team is joined by climate scientist Peter Stott to talk about oil giant Exxon's knowledge of climate science in the 1970s.

newscientist.com/nspod



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Particle smasher Learn about research at the Large Hadron Collider

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Wonder material Wool is surprisingly versatile, but is it green?

Video

Insect farming

Take a look inside French company Ÿnsect's pilot facility on our YouTube channel this week. The biotech firm plans to open 15 mealworm factories by 2030 to provide an alternative source of protein for the growing human population, following the 2021 decision by the European Union to approve the use of the beetle larvae for human consumption.

youtube.com/newscientist

Newsletter

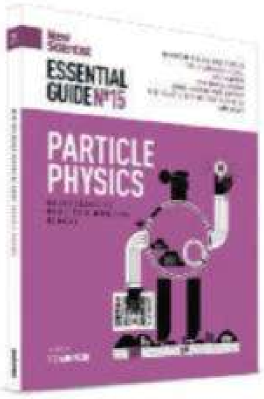
Fix the Planet

Wool from sheep farming often goes to waste, says environment reporter Madeleine Cuff, but some people are using it instead as insulation. It may even help to strengthen concrete. But as sheep farming is a source of significant carbon emissions, it is difficult to calculate wool's green credentials.

newscientist.com/ fix-the-planet

Podcast

"This is a story of a sea that rises but crucially doesn't recede, and how to survive it"



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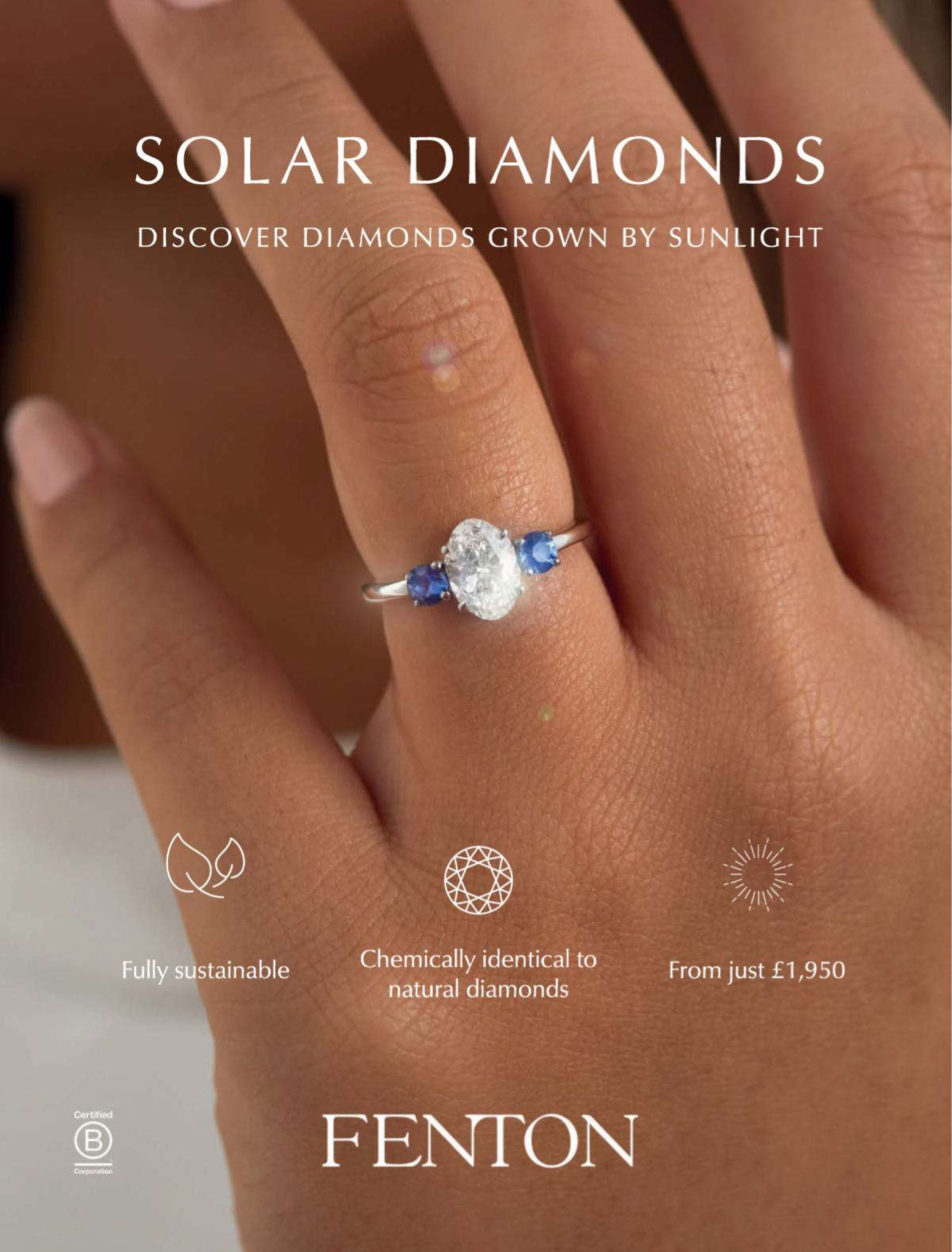
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Disentangling depression

We may be entering a bold new era in the treatment of this debilitating condition

CONTROVERSY has surrounded the most popular class of antidepressants ever since their development in the 1990s. Initially seen as wonder drugs, we have since come to realise that these selective serotonin reuptake inhibitors, or SSRIs, don't help everyone and can cause unpleasant side effects.

The most recent cause for concern is that the once widely accepted explanation for how SSRIs work – namely by mitigating a lack of the brain chemical serotonin – is no longer thought to be correct. The unsettling conclusion is that, although the drugs work for many, we don't know why.

It is clear that depression is a lot more complicated than we thought and that developing better treatments is therefore going to be more complicated too. For one thing, it seems that there may be many different types of depression, each underpinned by different mechanisms.

But there are reasons to think we are taking the first tentative steps into a new era for the treatment of depression. Several fresh ideas about its biological causes are on the table, some of which have already led to new treatments, as we explore on page 38. Researchers are also developing tests for "biomarkers" that would tell people which kind of depression they have and which treatment is most likely to benefit them.

> "Several fresh ideas about the biological causes of depression are on the table"

Another cause for optimism is that stigma around seeking medical or psychological help for depression is starting to fade. Although there is still some way to go before mental health conditions are viewed in the same way as physical ones, these days, more people are open about their mental health issues and this may encourage others to seek help when they need it.

One thing is for certain: a revolution is sorely needed. Depression has always been part of the human condition and it can be just as debilitating as more visible physical health problems. There are no simple solutions and it won't happen overnight, but the sooner we have a wider range of more effective treatments, the better. ▮

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REUTERS/CHRISTIAN MANG

Energy

Clash over coal

Police in Germany removed activists protesting the planned expansion of a coal mine after the government gave the go-ahead, reports **Madeleine Cuff**

HUNDREDS of climate activists, including Greta Thunberg, have been removed by police from protest sites around the German village of Lützerath. Activists have been squatting there for more than two years in protest at the planned expansion of the Garzweiler coal mine by German energy company RWE.

RWE owns the village and almost all of its original residents have been evicted. Police launched a large operation to clear the area of activists on 11 January, after the German government came to an agreement with RWE that the demolition of the village and the mine's expansion could go ahead. Ministers say the project is necessary for Germany's energy security.

In return for permission to expand Garzweiler into Lützerath, RWE has agreed to remove coal from its power supplies by 2030, eight years earlier than planned, and to scrap plans to expand the mine into other surrounding settlements.

Climate protesters say an expansion of coal mining activity will accelerate climate change and undermine the German government's promises to tackle climate change. One told the BBC that digging new coal is akin to "throwing the Paris Agreement in the bin". Lignite coal, which is mined at Garzweiler, is the most polluting fossil fuel.

Speaking on 14 January as part of a large rally in fields just outside Lützerath, Thunberg said Germany is "embarrassing itself right now" by allowing the expansion of the coal mine. She was photographed being removed by the police from a nearby protest site on 15 January, according to German newspaper *Bild*, alongside other protesters. In total, German police say they have removed around 300 activists from Lützerath and the surrounding area in recent days.

A protester in Lützerath, Germany, on 11 January

Earth systems

El Niño may push us past 1.5°C mark

A predicted shift in the world's climate pattern would increase the global average temperature

Madeleine Cuff

A GLOBAL shift to an El Niño climate pattern later this year could pave the way for the world to breach 1.5°C of warming for the first time in 2024, according to the UK Met Office.

New modelling from the agency suggests the current three-year La Niña phase will end in March and this looks likely to be followed by an El Niño pattern later this year. "At the moment, the vast majority of forecasts are going into El Niño in the latter half of 2023," says Adam Scaife at the Met Office.

El Niño and La Niña are terms used to describe fluctuations in Earth's climate system, driven by changing sea surface temperatures in the equatorial Pacific. El Niño is declared when sea temperatures in the tropical eastern Pacific rise 0.5°C above the long-term average. La Niña describes the other side of the fluctuation, when eastern Pacific temperatures drop below average.

Both phenomena trigger shifts in weather patterns around the world, affecting everything from heatwave risks in Australia to rainfall patterns in Chile. Because El Niño events bring higher than average temperatures, they can also temporarily drive up the global average temperature.

A shift later this year to a strong El Niño that pushes Pacific sea surface temperatures to 3°C above average could temporarily raise the global average temperature by 0.3°C, says Scaife. This would come on top of the existing 1.2°C increase in global temperatures since pre-industrial times, caused by rising emissions of greenhouse gases.

Taken together, it could mean that average temperatures in 2024 may reach 1.5°C above pre-industrial levels, he says. "If you add on a big El Niño… then we're going to get close, potentially, to the first year of 1.5 degrees," he says.

El Niño brought flash flooding to Peru in 2017

ERNESTO BENAVIDES/AFP VIA GETTY IMAGES

Last month, the Met Office predicted that 2023 could be one of Earth's hottest years on record, an expectation partly driven by an anticipated swing to El Niño.

A global shift to El Niño could bring rain to parts of Chile, Argentina and the south-west US, which have experienced lengthy droughts as a result of La Niña.

But it would probably disrupt Indonesia's monsoon season, impacting rice production in the country, and increase the risk of severe heatwaves and wildfires in Australia. Warmer sea temperatures also bring a heightened threat of bleaching in tropical coral reefs.

However, some researchers caution it is too early to tell how strong any El Niño might be. A mild El Niño would raise global temperatures, but not enough to breach 1.5°C.

"It's probably a better than 50/50 bet that there will be an El Niño [later this year]," says David Battisti at the University of Washington in Seattle. "How big it's going to be is anybody's guess."

Others say it is too early to say for certain there will be an El Niño this year. Pedro DiNezio at the University of Colorado Boulder points out the uncertainties in predicting the occurrence of El Niño this early in the year, before the so-called spring predictability barrier. DiNezio likens the accuracy of El Niño prediction models to "weather forecasting 30 years ago".

"This early in the year, I would not bank on an El Niño happening," says DiNezio. ▮

Atmospheric physics

Tonga eruption will have short-term warming effect

THE chances of temporarily seeing global warming pass 1.5°C within the next five years have risen markedly due to the spectacular eruption of an underwater volcano in Tonga in January 2022.

The explosive Hunga Tonga-Hunga Ha'apai event was the most powerful of the 21st century so far. Large eruptions are usually dominated by sulphur dioxide emissions, which cause climate cooling, but the Tonga one was very unusual because it released a lot of water vapour – a powerful greenhouse gas.

Satellite measurements indicate that it increased the water vapour content of the stratosphere by 10 to 15 per cent. This is expected to cause temporary global warming.

Stuart Jenkins at the University of Oxford and his colleagues estimated how the extra water vapour would change the balance of incoming and outgoing energy in the atmosphere. They then simulated the resulting temperature anomaly until 2035 under two scenarios: one in which carbon emissions continue on their current trajectory and one with ambitious climate mitigation policies.

10-15%

Estimated increase in water vapour in the stratosphere from Tonga volcano

They found that on the current emissions trajectory, the Tonga eruption will produce a small and short-lived warming effect, increasing the chance from 50 to 57 per cent of at least one of the next five years reaching 1.5°C above pre-industrial levels for the first time (*Nature Climate Change*, doi.org/jsv3).

In the ambitious climate mitigation scenario, the chances of one of the next five years exceeding 1.5°C actually rises to an even

What will happen if we pass the key 1.5°C milestone?

A single year above 1.5°C of global warming won't mean we have failed to meet the tougher Paris goal, but the political fallout would still be huge

THE threat of not one but two routes to exceeding 1.5°C should focus all of our minds. As the other stories on these pages suggest, human-made climate change has left us at the whims of Earth's temperature fluctuations, and brought us close to a milestone no one ever wanted to hit.

The world has already warmed by about 1.2°C since pre-industrial times. Within the next four years, there is a 48 per cent chance of breaching the 1.5°C threshold for the first time, according to the UK Met Office. At most, we have nine years until exceeding 1.5°C at least once is inevitable, according to the Global Carbon Project.

> **"The 1.5°C target has become a guiding light for the climate movement since the Paris Agreement"**

This would be totemic. The 1.5°C target has become a guiding light for the climate movement, after it was included as a "stretch goal" in the 2015 Paris Agreement, with the world's nations promising to limit any global rise in average temperatures to "well below" 2°C and to strive for warming of no more than 1.5°C.

That inclusion of 1.5°C in the deal – fought for by campaigners and small island states at risk of rising seas – focused scientific minds. In 2018, the Intergovernmental Panel on Climate Change published a report on the impact of exceeding the 1.5°C target, warning that going beyond this level would be far more damaging than first thought.

Suddenly, the 1.5°C goal was the only target in town. With the science clear that 2°C would devastate some of the world's most vulnerable communities, 1.5°C became central to conversations about climate equity and justice, as well as global ecological and financial stability.

Politicians and business leaders developed "net-zero" targets designed to deliver carbon cuts in line with the 1.5°C goal. The UK hosted the COP26 summit in 2021 with the explicit aim of "keeping 1.5°C alive". By 2021, 80 per cent of the global economy was covered by net-zero pledges.

WORKING
1·5
WHAT A WAY TO SAVE A PLANET

VUK VALCIC/ALAMY

Climate protesters in London in November 2021

In the eyes of many, limiting warming to 1.5°C has become the defining measure of success in the climate fight, even as many scientists privately warn that the goal is no longer in reach. With the first breach of the threshold, that sense of hope and urgency could come crashing down. The first breach would be temporary, driven by a short-term surge in temperatures due to a powerful El Niño climate pattern (see left) or a blast of climate-warming water vapour from a volcanic eruption (see below) or both.

It won't count as a failure of the Paris Agreement, as those temperature goals will be assessed based on the average temperature over 20 to 30 years. By 2030, it will become clear whether or not the world has made the emissions cuts necessary to limit warming to 1.5°C over the long term. Based on current rates, that seems highly unlikely.

However, overshooting 1.5°C, if only for a year, would be a crushing development and the political fallout would be huge. World leaders would be accused of making empty promises and business leaders harangued for polluting the world in pursuit of profit.

In the face of failure, some might propose increasingly radical – and risky – options to save the planet, like geoengineering. Others might throw their hands up in despair and lean into populist anti-climate rhetoric, particularly alongside escalating calls for climate compensation from vulnerable countries.

For the climate movement, the sense of urgency that has energised activists could dissipate. If 1.5°C is no longer possible, can they convincingly recreate the same momentum for 1.6°C, or 1.7°C?

When it comes to climate change, every fraction of a degree matters. But as the 1.5°C threshold looms ever closer with each passing year, what comes next is becoming a crucial question – one that those involved in climate action must start to grapple with. ▮ **MC**

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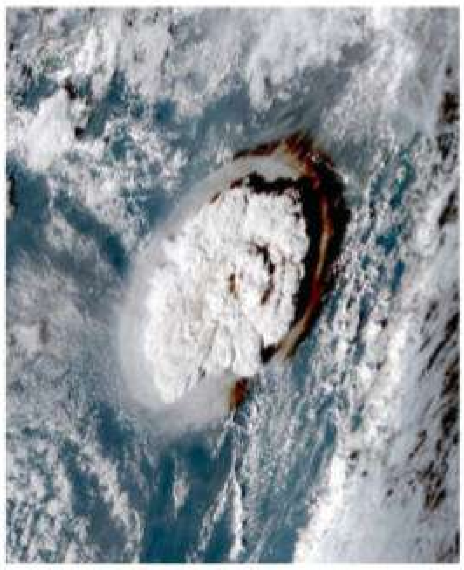
higher level, from 60 to 67 per cent. That is because aerosol particles from human air pollution reflect radiation and currently help to slow the pace of warming, but ambitious mitigation policies cut emissions of pollutants quickly, resulting in faster rates of warming in the short term.

Exceeding 1.5°C of warming in a coming year because of this wouldn't mean we have failed to meet the Paris Agreement goal, says Jenkins. "Whilst Tonga may increase our chances of seeing a 1.5°C year in the near term, it is a natural influence on the climate system and doesn't contribute to our measures of success or failure in the Paris Agreement," he says. The research shows the Tonga effect will have disappeared by 2035.



CSU/CIRA AND JAXA/JMA

Satellite photo of the Hunga Tonga-Hunga Ha'apai volcano eruption in January 2022

"This is a timely study and demonstrates that we can relatively quickly estimate the impact that a volcanic eruption will have on surface temperature," says Anja Schmidt at the Ludwig Maximilian University of Munich, Germany.

"Even though most volcanic eruptions cool the Earth's surface, this study demonstrates that only rapid and rigorous reductions in anthropogenic emissions will substantially decrease the risk of exceeding very dangerous levels of warming," she says. "We can't rely on the short-term cooling effect of most volcanoes to save us from the impacts global warming will have." ▮

Kate Ravilious

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Animal behaviour

Warmer egg incubators make male chicks more sociable

Christa Lesté-Lasserre

DANCU ALEKSANDAR/GETTY IMAGES

Greater harmony can raise the well-being of farmed chicks

RISING global temperatures mean that many researchers are looking for ways to stop farmed chickens from overheating. This could involve exposing eggs to slightly higher temperatures during incubation, with previous research suggesting promising outcomes.

However, the behavioural consequences in adult chickens of this approach are less clear, particularly in terms of how it could affect the sociability and aggressiveness of males, which influences flock well-being.

To learn more about this, Tomas Norton at KU Leuven, Belgium, and his colleagues put 60 high-quality chicken eggs in three identical incubators.

They first set each incubator to the standard temperature of 37.6°C used in hatcheries, which reflects the conditions experienced in a natural nest under a laying hen.

The researchers then increased the temperature of one incubator by 1°C, while another was raised by 2°C. Both were set to these temperatures for 8 hours a day, from days 15 to 20 after laying. Chicken eggs typically hatch on day 20 or 21. For the remaining 16 hours of the day, all the incubators were at 37.6°C.

After hatching, all the chicks were kept in identical temperature-controlled conditions. Over the next six weeks, the researchers ran a series of behavioural tests.

The results show that the males exposed to the standard incubation temperature as eggs were generally less sociable than the equivalent females. Sociability was measured by how vocal the chicks were when isolated for 3 minutes and how much time they spent in a "social zone" close to other chicks during the tests.

The male chicks that were incubated at 1°C or 2°C above the standard temperature were almost twice as vocal as the female equivalents when isolated for 3 minutes. The males in the 2°C group also spent twice as much time in the social zone, compared with those in the 1°C and standard hatchery temperature groups (*Applied Animal Behaviour Science*, doi.org/jsv8).

> "Males could be made less aggressive towards females, improving welfare in the flock"

Given the crowded living conditions in most chicken farms, increased sociability may make these male birds less aggressive towards the females and therefore improve the overall welfare of the flock, says Norton.

Why a higher incubation temperature affects male behaviour is unclear, but temperature variations probably also occur in natural nests. "The eggs in the middle lose heat more slowly than the eggs on the outside," says Norton. "Our hypothesis is that maybe the end result is a group of chicks with different personalities."

The research focused on male chicks, although early results suggest similar effects may occur among females, but to a much lesser extent.

In commercial farms, adult males are often aggressive towards other chickens, including females, says Norton. If longer-term studies confirm the results of this research, slightly overheating incubated eggs could not only make chickens more resilient to climate change, but also improve their welfare, he says. Coping with warmer conditions may also be beneficial as poultry production increasingly moves to hotter countries for global consumption, says Norton. ▮

Research

Scientific journals overly print papers by their own editors

Clare Wilson

MORE than 1 in 10 researchers who are also editors of a science journal publish a fifth of their own papers in their journal – and 1 in 20 publish a third of their work in them. This raises the question of whether editors' submissions get treated more favourably.

Bedoor AlShebli at New York University Abu Dhabi, the United Arab Emirates, and her colleagues analysed more than 1000 journals published between 1980 and 2018 by the company Elsevier.

Overall, 12 per cent of these journals' editors published more than a fifth of their papers in their journals and 6 per cent published more than a third in them.

The team used software to match each editor with a similar researcher, for example one in the same scientific field. The results show that these comparison researchers generally had only a small percentage of their papers accepted by the journal (*Nature Human Behaviour*, doi.org/jswg).

"Publishing in a journal is supposed to be a signal that the journal thought this is good-quality science," says Stuart Buck, who runs the Good Science Project, a non-profit US organisation. "At the very least, [self-publishing] seems like a conflict of interest."

Dorothy Bishop at the University of Oxford says some editors may try to publish high-quality science in their own journals to improve its profile, rather than to boost their own careers. In such cases, the scientists should step back from editorial board decisions on whether to accept the work and state in the paper that this has happened, says Bishop.

A spokesperson for Elsevier says editors can publish in its journals, but they shouldn't be involved in decisions about such papers and there must be a clear statement to this effect on publication. ▮

Health

Ultrasound rejuvenates cells

Treatment with low-frequency ultrasound has restarted cell division in ageing human cells and reinvigorated old mice, reports **Michael Le Page**

LOW-frequency ultrasound appears to have rejuvenating effects on animals. As well as restarting cell division in ageing human cells, it has reinvigorated old mice, improving their physical performance in tests such as running on a treadmill and making one old mouse with a hunched back move around normally again.

"'Is this too good to be true?' is the question I often ask," says Michael Sheetz at the University of Texas Medical Branch, whose team is planning to start a small trial in people to see if the technique is safe and can help treat age-related diseases. "We're examining all aspects of it to see if it really does work."

After a certain number of divisions – known as the Hayflick limit – the cells in our bodies stop dividing, becoming senescent. Stresses such as toxic chemicals can also make cells become senescent.

This can have knock-on effects because some senescent cells secrete chemicals that cause inflammation or induce senescence in other cells. The growing proportion of senescent cells in various tissues in our bodies as we get older is thought to be one of the main causes of ageing and age-related diseases.

"We treated the old mouse twice with ultrasound and it was back to behaving normally"

For this reason, many people are trying to develop treatments that involve killing off senescent cells.

But another approach could be to use low-frequency ultrasound to rejuvenate them.

Sheetz's team has found that low-frequency ultrasound makes senescent cells from monkeys and humans resume dividing and halts the secretion of chemicals that promote senescence. The researchers used ultrasound with a frequency of less than 100 kilohertz, well below the 2000 kHz or so used for medical imaging.

Human foreskin cells usually show signs of senescence after about 15 divisions, for instance, but with ultrasound treatment reached 24 divisions with no signs of abnormalities. The team is continuing the experiment to see what the limits are.

Dramatic improvements

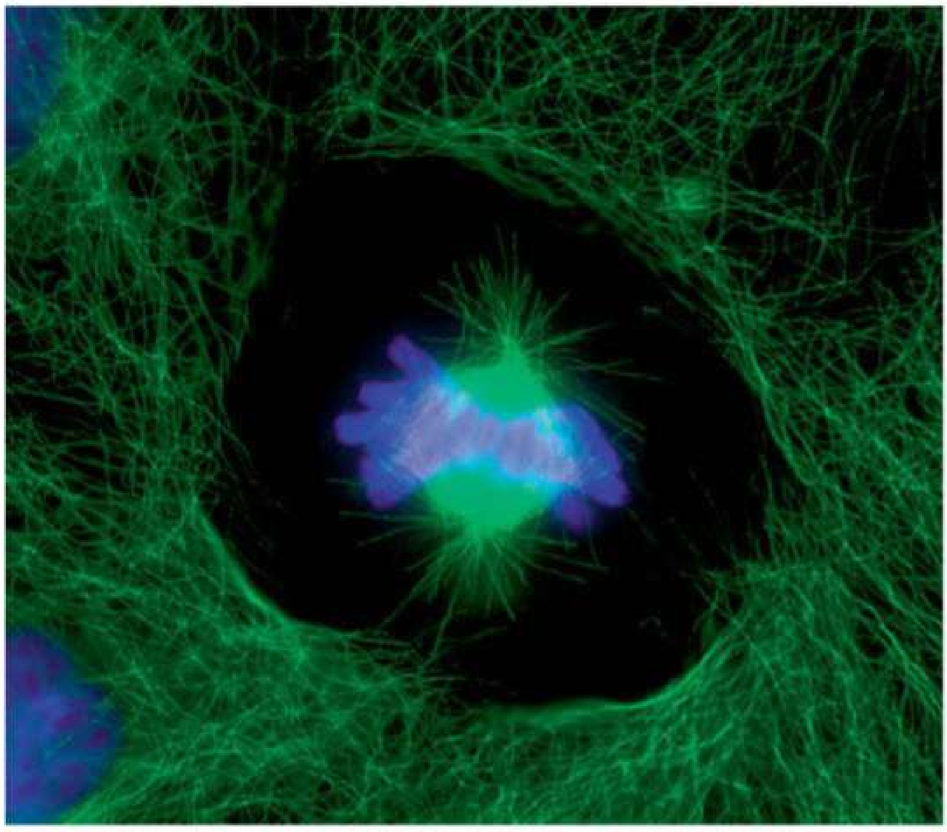
Extending the Hayflick limit could be useful for growing cells for research or for treating people. Sheetz plans to start selling ultrasound devices to other labs so they can try this.

His team also treated entire animals by placing mice aged between 22 and 25 months in warm water deep enough to cover at least half of their bodies, because ultrasound waves lose less power travelling through water than they do through air. Mice treated with ultrasound improved in physical tests compared with mice that were put in the warm water but weren't given ultrasound.

In some cases, improvements were dramatic, says Sheetz. One old mouse had a hunched back and wasn't moving well, and it did the worst in the initial tests. "We treated it twice with ultrasound and it was back to behaving normally," he says. "I don't think that rejuvenation is too strong a term."

The team also used fluorescent dyes that bind to senescent cells to show that the proportion of these cells in the kidneys and pancreas of mice decreased after the treatment (bioRxiv, doi.org/jsv5).

Why ultrasound has these effects isn't clear. "Aspects of this are still mystifying," says Sheetz.



A human cell (centre) dividing during mitosis, the process that creates new cells

DR TORSTEN WITTMANN/SCIENCE PHOTO LIBRARY

However, his hypothesis is that the physical distortion of cells by ultrasound has effects similar to that of exercise. In particular, it may be reactivating the waste disposal systems inside cells, which grind to a halt in senescent cells.

<100kHz

The frequency of ultrasound waves used to rejuvenate cells

Are the findings convincing? "Generally, yes," says Jürgen Götz at the University of Queensland in Australia. "But I think more work is needed to define the effective ultrasound parameters." It will also be difficult to apply to people, he says, given that bones and lungs block ultrasound transmission.

Götz's team has found that mice given a higher frequency of ultrasound show improvements in memory, and a small trial is under way to see if this can help people with Alzheimer's.

Ultrasound has, for decades, been used as a therapy for a wide range of conditions, but typically treatments used hand-held devices and higher frequencies of ultrasound than Sheetz and his team's approach. The results have been mixed. The use of different equipment and methods is a major problem in assessing efficacy, say Goetz, as it makes it very hard to compare studies.

Sheetz and his team are planning a trial involving people with osteoarthritis, who will immerse their bodies in water to be treated, and people with diabetic foot ulcers, who will be treated using foot baths. Any therapy that boosts cell division could theoretically increase the risk of cancer, but Sheetz says his team has seen no sign of this. ▮

Technology

Ranchers in the US test virtual fences to track and move cattle

James Dinneen

ASTRID860/ISTOCKPHOTO/GETTY IMAGES

Dairy cows wearing collars fitted with GPS trackers

HERDS of cattle in Colorado are roaming nearly free, penned in not by physical fences, but virtual ones. They are part of a test by the US Bureau of Land Management (BLM) to use virtual fencing across about 2000 square kilometres of land. Farmers or ranchers direct herd movement with an app and GPS-enabled collars, which could one day be combined with AI to help better manage livestock.

"We're dealing with computers, and we're dealing with cows", so everything doesn't always go to plan, says rancher Clayton Gerard. Still, the virtual fences he has used for the past year to manage cattle grazing in the Rocky mountains have mostly been a success.

Each animal is fitted with a collar that makes warning sounds when approaching a virtual boundary and delivers an electric shock to deter them from crossing it. An app lets farmers and ranchers draw and redraw boundaries to drive cattle to more evenly graze the range, reducing soil erosion. Users can also set the virtual fence to automatically herd animals from point to point.

Training stubborn, older cows to respond to the collars has been hard, says Gerard, and the system would be too expensive without government support. But "it's going to be a major tool", he says. His cattle are some of the more than 90,000 cows, sheep and goats around the world now being managed with virtual fences. The idea isn't new, but improvements in GPS, batteries and cellular networks have made it a reality, says Kristy Wallner at BLM.

Norwegian company Nofence has sold around 50,000 collars, according to CEO Knut Bentzen. He showed *New Scientist* a map of the real-time location of every animal, from clusters of sheep in the UK to cattle in nearly every US state and parts of Europe. The Colorado project uses collars from US company Vence, which are on 40,000 animals in the US and Australia. Vence also installs radio towers to connect to collars in areas with poor cellular reception.

The collars raise animal welfare concerns, says Anne Cathrine Linder at the Technical University of Denmark. But animals can learn to respond to the sound they make alone, limiting shocks, and her research on virtual fencing shows it doesn't seem to stress cows.

Virtual fences are especially useful for temporary fencing. For instance, they kept livestock out of an area in south-east Oregon burned by fire, helping sagebrush regrow. "It's not an iron gate," he says. "If you've got cattle next to an interstate [highway], you don't want virtual fencing."

The US West has around 1 million kilometres of fencing, which can block migrating wildlife such as elk and pronghorn, says Alex McInturff at the University of Washington in Seattle. Virtual fencing hasn't yet been paired with widespread fence removal, but the Colorado project has led to the removal of some old fences and avoided some new ones.

"We're not about replacing the cowboy," says Frank Wooten, CEO of Vence. "We're replacing the part of their job they like the least." ▮

Space

Supermassive black hole keeps snacking on the same star

NEARLY 900 million light years away, a supermassive black hole has the munchies. Every 1200 days or so, the same orbiting star gets a bit too close and the black hole takes a bite in a process called a repeated partial tidal disruption event (TDE).

This TDE, designated AT2018fyk, is only the second ever found to repeat itself. The first bite that astronomers spotted was in 2018, when the black hole – which has a mass 6 billion times that of the sun – suddenly brightened and stayed bright for about 600 days. This happens when a star gets too close to a black hole, at which point it gets shredded by the powerful gravitational field, creating a stream of hot, bright stellar material that then falls into the black hole and dims again. Once this particular TDE died down, astronomers thought that was the end of it.

But years after the black hole finished its snack, something strange happened. "Almost four years after it was originally detected, we went back and looked at this object again and found that it was once again bright… That's really, really weird," said Eric Coughlin at Syracuse University in New York, who presented the work at a meeting of the American Astronomical Society in Seattle.

The second brightening looked almost identical to the first. This led Coughlin and his colleagues to suggest it was simply a second bite taken from the same star. Instead of shredding the star entirely, the black hole seems to be ripping off pieces of it every time it gets too close, leaving the core of the star to continue on another orbit.

"The black hole seems to be ripping off pieces of the star every time it gets too close"

On each pass, the black hole devours somewhere between 1 and 10 per cent of the star. "If it's 10 per cent, then it's more likely that this thing is only going to survive for maybe two or three more encounters with the supermassive black hole," said Coughlin. "If it's 1 per cent… maybe we've got a couple decades." ▮

Leah Crane

Climatology

Exxon predicted climate change

Scientists working for the oil company in the 1970s foresaw how the planet would warm

Madeleine Cuff

EXXON scientists predicted the pace and scale of climate change more than 40 years ago, according to a study that its authors say adds weight to claims the oil firm knew about and sought to downplay the risks posed by continued fossil fuel use.

Scientists working for Exxon between 1977 and 2003 accurately forecasted the rate at which global average temperatures would rise as a result of carbon emissions, correctly predicted that human-caused global warming would first be detectable by around 2000 and reasonably estimated how much carbon dioxide would lead to dangerous warming, according to the study.

Leaked internal documents published in 2015 suggest Exxon, which became ExxonMobil in 1999, was aware of climate change in the 1970s and knew the threat could cause "dramatic environmental effects before the year 2050".

But this is the first time Exxon's quantitative climate projections have been assessed. Geoffrey Supran, then at Harvard University, and his colleagues analysed all publicly available internal documents and research publications disclosed by the firm between 1977 and 2014 to assess the accuracy of Exxon's scientific predictions against contemporary models and subsequent real-world changes in temperature.

The results were in line with scientific thinking at the time of writing, the team found.

ExxonMobil denies seeking to cover up climate change

Meanwhile, 63 to 83 per cent of the projections were accurate in predicting later rates of global warming (*Science*, doi.org/grmt2g).

"Most of Exxon's projections accurately forecast warming, consistent with subsequent observations, but also at least as skillfully as those of independent models," says Supran. "Excellent scientists modelled and predicted global warming with shocking skill and accuracy, only for the company to spend the next couple of decades denying that very climate science."

JHVEPHOTO/ISTOCK/GETTY IMAGES

ExxonMobil is one of a number of oil companies facing lawsuits in the US accusing them of seeking to conceal the true impact of fossil fuel use from the public.

Supran says Exxon took a "two-handed" approach to the issue of climate change. "In private and academic circles, they contributed quietly to climate science," he says. "But at the very same time, and then thereafter, they contributed loudly to promoting doubts about that very science."

In response to the findings, an ExxonMobil spokesperson denied accusations it had sought to cover up the science of climate change and said the firm is "committed to being part of the solution to climate change and the risks it poses". In the statement, they said: "Those who suggest 'we knew' are wrong. Some have sought to misrepresent facts and ExxonMobil's position on climate science, and its support for effective policy solutions, by recasting well intended, internal policy debates as an attempted company disinformation campaign." ▮

Palaeontology

Trilobites used trident-like horns to fight over mates

TRIDENT-LIKE horns on the heads of some trilobites were probably used in fights over mates. This behaviour would be the oldest example of sexual combat that has been identified in the fossil record.

"Extraordinary structures in organisms cry out for functional explanations," says Alan Gishlick at Bloomsburg University in Pennsylvania.

Previously, palaeontologists had suggested that the three tines on *Walliserops*, a trilobite that lived around 400 million years ago, could have been used as a defence against ancient nautilus that were hungry for these marine invertebrates. The prongs could grow to more than 25 millimetres long, nearly the size of the rest of the animal.

But Gishlick and his colleague Richard Fortey at the Natural History Museum in London have come to a different conclusion, after studying an unusual specimen of *Walliserops* with four tines instead of three.

The four-pronged trilobite was comparable in size to other adult *Walliserops*, indicating that it had the expected lifespan for its species. This appears to be evidence against the trident being a defensive weapon, as such an abnormality in a defensive structure might have made the trilobite more vulnerable (*PNAS*, DOI: 10.1073/pnas.2119970120).

Structures used in competition for mates are less critical to survival. "We know there is a high degree of tolerance for malformation in structure related to sexual selection because they only affect mating," says Gishlick. Modern Japanese rhinoceros beetles (*Trypoxylus dichotomus*) have similar structures jutting from their heads, used in courtship competitions. Male beetles often have variations or abnormalities in horn shape .

> "It is amazing to see that such complex behaviours appeared very early in the course of evolution"

"It is amazing to see that such complex behaviours appeared very early in the course of evolution and have endured to the present day," says Jean Vannier at the University of Lyon, France. ▮

Riley Black

Food science

Chocolate's melting mouthfeel depends on fatty exterior

Matthew Sparkes

CHOCOLATES with a high-fat exterior and low-fat centre could provide the same pleasing taste and melting consistency, but with fewer calories, say researchers.

To explore the factors that determine the mouthfeel of chocolate, Anwesha Sarkar at the University of Leeds, UK, and her colleagues used an artificial tongue 3D-printed in silicone to mimic the texture and elasticity of the human tongue.

The melting of fats in the mouth produces droplets that are thought to create the pleasing sensation and texture of chocolate. The team found that the fats on the surface of the chocolate are most vital of all. After that, solid cocoa particles in the chocolate become important to the experience (*ACS Applied Materials & Interfaces*, doi.org/jsqp).

"What we realised is that fat is definitely a very important material, but you don't need to distribute the fat [throughout the chocolate]," says Sarkar. "The main point where the fat content matters is the surface layer. Once you start eating the chocolate, breaking it down into pieces, then you're not getting so much benefit of the fat content."

SEBASTIAN DUDA/SHUTTERSTOCK

Chocolate transforms from solid to liquid in the mouth

But Barry Smith at the School of Advanced Study in London says he is sceptical that a fatty coating alone can provide the same sensation. "Eating a piece of chocolate is a multi-sensory experience," he says. "I don't think messing around with a single parameter is a guaranteed way forward here." ▮

Analysis **Artificial intelligence**

Should schools ban AI chatbots?

Many educators want to limit access to these powerful tools, but some say it would be better to make them part of the curriculum, finds **Jeremy Hsu**

SHOTSHOP GMBH/ALAMY

The ChatGPT AI can produce convincing essays on many topics

SCHOOLS in the US and elsewhere are announcing bans on the recently released AI-powered chatbot ChatGPT out of fear that students could use the technology to complete their assignments. However, bans may be practically impossible given how difficult it is to detect when text is composed by ChatGPT. Is it instead time to rethink how students are taught and evaluated?

"Educators are starting to question what it means to… assess student learning if an AI can write an essay or paper similar to, or even better than, a student would – and the teacher can't tell the difference", says Torrey Trust at the University of Massachusetts Amherst.

The ChatGPT AI developed by the company OpenAI displays an uncanny ability to answer conversational prompts and write coherent – if not always factually accurate – text summaries. It attracted 1 million users just days after first going public on 30 November 2022 and prominent school systems soon began to ban it outright.

The Los Angeles Unified School District in California, the second largest school district in the US, pre-emptively blocked access to ChatGPT on networks and devices in December 2022. That was followed in January 2023 by a ChatGPT ban from New York City's Department of Education, which oversees more than 1 million students. Leading Australian universities have decided to emphasise pen and paper exams and oral presentations in order to thwart students from turning in AI-generated essays.

Removing technology from the classroom can mean undesirable consequences, such as creating more obstacles for students with disabilities, says Trust. Additionally, restricting access to ChatGPT on school networks and devices can't stop students from using the chatbot at home and in libraries.

1m

The number of users of ChatGPT just days after it went live

It is also unclear if anti-cheating software can reliably detect AI-assisted writing. OpenAI is working to develop a digital watermark that can help teachers and academics spot students who are using ChatGPT to write essays.

"ChatGPT provides a tempting opportunity for students to exhibit their technological prowess, as well as attempt to gain advantage on their professors in the cheating 'arms race'," says Jo Ann Oravec at the University of Wisconsin-Whitewater. "Blocking the program on university campuses will be nearly impossible."

Instead of worrying about how ChatGPT could enable cheating, educators should ask what motivates students to cheat in the first place and work on developing relationships of trust, says Jesse Stommel at the University of Denver in Colorado.

"Talk to students really frankly about what ChatGPT's capable of, what it's not," says Stommel. "Have students use it to write an essay about Jane Austen and gender dynamics, and then have them read that essay and peer review it and think about what ChatGPT gets right and wrong."

School bans also overlook the possibilities for how ChatGPT could help with time-consuming tasks, says Aakash Chowkase at the University of California, Berkeley. He has explored using the AI to help create lesson plans, write letters of recommendation and develop and grade assignments. He recently held a ChatGPT workshop for teachers in India. "Our ultimate goal is to help learners," says Chowkase.

Similarly, Trust has publicly shared slides intended to help teachers understand some of the promise and pitfalls of using ChatGPT in education. "I just wish educators could see that AI writing tools are going to be part of our future – and a big part of students' future careers," says Trust. ▮

Neurology

One brain network may be involved in six different mental health conditions

Clare Wilson

THE causes of many mental health conditions, such as schizophrenia, obsessive-compulsive disorder (OCD) and bipolar disorder, are poorly understood. Now, new research suggests that disturbances to a network of brain regions may be involved in the onset of these conditions, along with three others.

The claim comes from an analysis of collections of medical data, with the authors concluding that problems within the same brain network may be involved in depression, anxiety, addiction, OCD, schizophrenia and bipolar disorder.

Brain-scanning studies have previously suggested that several different areas of the brain are linked with various mental health conditions, but their results were inconsistent, says Joseph Taylor at Brigham and Women's Hospital in Boston, Massachusetts. Taylor and his colleagues wondered if that inconsistency was because different brain regions within one network all play a role.

KATERYNA KON/SPL/ALAMY

A brain circuit has been linked to conditions like OCD and schizophrenia

To learn more, the team looked at the health records of 194 Vietnam war veterans who had a physical injury to their brain. The veterans were more likely to be diagnosed with multiple mental health conditions, including the six previously mentioned, if they had damage to regions towards the back of the brain, including in an area called the posterior parietal cortex, which is linked with spatial perceptions.

They were less likely to have such a diagnosis if they had been injured near the front of the brain, including in the anterior cingulate, a region associated with emotions, and the insula, which is linked with self-awareness.

The researchers compared their findings with an existing map of brain connections. This revealed that when the identified regions at the back of the brain have low activity, the ones at the front tend to have high activity, and vice versa.

They also looked at 193 brain-scanning studies involving nearly 16,000 people. The researchers found that individuals with any of the six mental health conditions tended to have shrunken tissue in the regions at the front or in other areas linked to them (*Nature Human Behaviour*, doi.org/jsqf).

Put together, the findings suggest that in people without any mental health condition, the back regions of the brain inhibit the front regions, while in people with damage to the back regions, the front regions become too active, which may lead to mental health conditions and tissue shrinkage, says Taylor.

He plans to boost brain activity in the posterior regions using a technique called transcranial magnetic stimulation as a potential treatment for mental health issues.

The findings fit with the idea that different mental health conditions share an underlying cause. The idea is controversial because conditions such as depression and schizophrenia have very different symptoms.

> **"The results add to the weight of evidence that psychiatric disorders share vulnerabilities"**

"Their results add to the growing weight of evidence that most psychiatric disorders share vulnerabilities," says Terrie Moffitt at Duke University in Durham, North Carolina. ■

To read about why we have got depression all wrong, see page 38

Conservation

Protected areas fail to stop loss of insects and spiders

PROTECTED areas in Britain are losing invertebrate species at the same rate as areas with no protection, prompting a call for more effective management of land assigned for conservation.

Rob Cooke at the UK Centre for Ecology & Hydrology and his colleagues looked at data from invertebrate monitoring carried out in England, Scotland and Wales between 1990 and 2018 to work out how widespread species are within protected and unprotected zones. The study included 1238 species of ants, bees, hoverflies, ladybirds, spiders and wasps.

The researchers found that while protected areas harboured greater species diversity than unprotected areas, over time, they lost species at the same rate, with pollinators such as bees and hoverflies particularly prone to losses (*Biological Conservation*, doi.org/jsvm).

In both protected and unprotected areas, 27 per cent of species present were either lost or gained between 1990 and 2018, with losses far exceeding gains. However, in contrast to previous work, common species showed a greater downward trend in areas with a conservation remit.

There are many likely reasons for this, says Cooke. "Conservation management definitely plays a role and more effective, evidence-based management would be great, but there's also a range of more pervasive pressures that need tackling more widely, such as climate change, pollution, insecticides and invasive species," he says.

ANTONY COOPER/ALAMY

Pollinator species, such as solitary bees, are particularly vulnerable to losses

The research "points at the landscape and institutional changes we urgently need", says Matt Shardlow, CEO of UK invertebrate conservation charity Buglife, noting that cuts to government agency budgets are affecting their ability to manage protected sites appropriately.

"Worryingly, many of our most internationally endangered invertebrate species do not even occur within the protected sites network," says Shardlow. ■

Gary Hartley

Is it time to ban gas stoves? There is mounting evidence that cooking on gas creates dangerous indoor air pollution and authorities are starting to take notice, finds **Madeleine Cuff**

FOR many restaurant chefs and enthusiastic amateurs, gas has long been the fuel of choice for stove-top cooking. But this love affair with the fuel could be coming to an end in the face of growing evidence of the health and climate threat it poses.

In an interview with Bloomberg News on 9 January, a commissioner for the US Consumer Product Safety Commission (CPSC) hinted that the agency is considering a ban on new gas stoves for public health reasons. Following a backlash from gas lovers, just two days later the CPSC said it had no plans for a ban.

Yet there are good reasons to reconsider gas. These stoves produce nitrogen dioxide and particulate matter – pollutants that are also found in traffic fumes – which can irritate lungs and increase the risk of heart disease and cancer. Children and older people are the most vulnerable.

About one in eight cases of childhood asthma in the US are due to the use of gas cookers, according to a recent meta-analysis of studies assessing the link between these stoves and childhood incidence of asthma. Based on these findings and survey data on gas stove use, the authors estimated the fraction of current childhood asthma cases attributable to gas stove use in nine US states (*International Journal of Environmental Research and Public Health*, doi.org/jsps).

The 1-in-8 headline figure is "very uncertain", says Frank Kelly at Imperial College London, who wasn't involved in the work. That is because of the study method of scaling up findings from previous research to population-wide outcomes, he says.

But it is clear that gas stoves are a "major source of indoor air pollution", says Kelly, which can exacerbate or even cause health conditions like asthma. "If the household has got an asthmatic child, they will have more symptoms [with a gas stove] than if they didn't have a gas stove," he says.

CHAD SPRINGER/CULTURA CREATIVE RF/ALAMY

Kitchens can have high levels of particulates and nitrogen dioxide

100m

people in the EU may be exposed to dangerous levels of indoor air pollution due to gas cookers

55%

is the amount venting cooker hoods can cut indoor pollution

Research has linked gas stoves to 1 in 8 US cases of childhood asthma

WAVEBREAK MEDIA LTD/ALAMY

Research into indoor air pollution is only just starting to catch up with outdoor pollution studies, having been held back for years by the challenges in shrinking measuring equipment to make it suitable for use inside homes. Now, the studies are coming thick and fast, showing that gas stoves cause spikes in indoor air pollution many times the levels on a busy city street. Kelly points to recent research in London, where children went to school wearing backpacks kitted out with air pollution monitors.

"Many of the children were actually exposed to more pollution at home in the evenings, when one of the parents was cooking, than what they actually were seeing on the way to school," he says.

Another study found that residents of southern California using gas stove tops are routinely exposed to nitrogen dioxide and formaldehyde levels that exceed safety thresholds for outdoor pollution set by US authorities. The problem is worse in smaller homes without adequate ventilation. "One could argue that the risk associated with a gas stove is likely to be larger than living in a polluted city," says Steffen Loft at the University of Copenhagen, Denmark.

The impact of gas cookers on climate change is another issue, and it isn't just the carbon emitted from the flame that is a problem. Last year, a team found that methane leaking from gas-burning stoves in the US has a climate impact comparable with the carbon dioxide emissions from about 500,000 petrol cars.

> **"One could argue that the risk attached to a gas stove is likely to be larger than living in a polluted city"**

The seemingly vast public health risk posed by these stoves means authorities may be starting to take notice. In the European Union, cooking on gas may be exposing over 100 million people to levels of indoor air pollution that would violate EU outdoor air pollution regulations, according to research published this month by the NGO Clasp. It is calling for all gas stoves to come with health warning labels.

However, policies related to climate change may force the issue first. By 2025, no new homes in the UK will be built with fossil fuel heating, a move that will almost certainly mean those homes are kitted out with electric induction stoves rather than gas ones. In the US, President Joe Biden's Inflation Reduction Act will offer households subsidies of up to $1340 to switch from a gas to induction stove.

Researchers agree that if people have the opportunity, they should change to electric cookers. This is a "relatively easy way of reducing your particulate matter and nitrogen oxide exposure", says Nicola Carslaw at the University of York, UK.

In the meantime, opening a window and using an extractor fan can make an immediate difference to indoor air quality, she says – effective cooker hoods that vent to the outside can cut pollution levels by 55 per cent, studies suggest. ■

Will passengers start to see red?

Justified action ...
or cynical disruption?

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Epidemiology

Genetic tracking scheme for viruses could warn of dangerous outbreaks

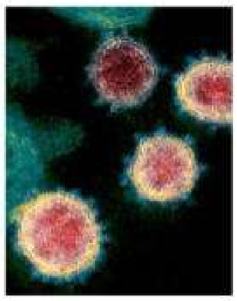
Michael Le Page

VIRUS samples from people in the UK with severe respiratory infections, such as flu and RSV, will be routinely tested by DNA sequencing. The project could lead to better treatments and vaccines, as well as earlier warning of dangerous new outbreaks.

The technology will be trialled on stored nose swabs from covid-19 tests starting later this year, before being rolled out more widely next year.

The team behind the project, called the Respiratory Virus and Microbiome Initiative, says it isn't aware of any similar plan elsewhere in the world, but it hopes other countries will adopt the same approach. To encourage this, it will be making all methods and data freely available.

"We hope it will be able to be used globally," says Ewan Harrison at the Wellcome Sanger Institute in Cambridge, UK, who is group leader on the project.


NIAID

Electron microscope image of SARS-CoV-2 coronavirus particles

While it has been possible to sequence viral genomes for decades, it was only during the covid-19 pandemic that many countries began to routinely sequence thousands of samples. This revealed how SARS-CoV-2, the virus behind the disease, was evolving faster than expected. Among other things, such genomic surveillance enabled researchers to detect the first omicron variants and correctly predict that they would cause a huge wave of cases around the world.

"For the first time in human history, large-scale genomics has provided governments and policymakers with forewarning of what's going to happen in an epidemic, and I think that's a really important and profound change," says Harrison. "It's something we think is really important to further build upon."

Many other viruses, such as RSV, can also cause serious respiratory infections, he says, but our current understanding of them is extremely limited. "Other than a small amount of genome sequencing in flu cases, there really isn't any routine genomic surveillance of these other viruses," says Harrison.

At present, the tests commonly used to identify viruses causing severe infections reveal only what type they are, such as rhinovirus or adenovirus, says Judith Breuer at University College London.

Sequencing the entire genome of a virus reveals much more information about it, which can be useful in many ways. It can help to ensure that people get the most effective treatments and can also lead to better vaccines, as was the case with mRNA booster shots that targeted the omicron variant of SARS-CoV-2. Genetic sequencing can also reveal how viruses are spreading and therefore help to contain them.

> "Sequencing the entire genome of a virus can help ensure that people get the most effective treatments"

Last, but not least, Harrison hopes to spot emerging new diseases early on. The odds of doing this will be much greater if other countries also do routine genomic surveillance.

"The methods and technologies that Ewan and the Sanger are developing will be extremely useful," says Breuer. "This is an amazingly important initiative." ▮

Animal behaviour

Lizards learn to fear wildfire more than predators

LIZARDS living in habitats recently scorched by wildfire are more alert to the sound of flames than those from nearby unburnt regions, suggesting their fire avoidance is learned rather than innate.

Lola Álvarez-Ruiz at the Spanish National Research Council noticed that many western fence lizards (*Sceloporus occidentalis*) survived wildfires in the US that wiped out other animals. "The species has a high survival rate, so we thought it must be adapting somehow to detect wildfire," she says.

SEAN BROMILOW/ALAMY

A western fence lizard sunbathing on a rock in San Diego, California

In 2019, she and her colleagues visited locations across California, including areas near Los Angeles recently burned by a wildfire and nearby unburnt wilderness and urban areas. They broadcast four sounds to lizards in each habitat: a raging fire, a falcon call, the chirps of a non-threatening finch and the trill of a bananaquit – a tropical bird the lizards wouldn't meet in the wild.

The researchers watched the lizards' faces through binoculars and counted glances towards the speaker to measure attentiveness to each noise. Lizards that lived in areas touched by wildfires the previous year showed immediate physical agitation and vigilance to the sound of a fire, glancing towards the speaker around 3.2 times per minute. Lizards without fire experience looked at the speaker once per minute (*Animal Behaviour*, doi.org/jsnk).

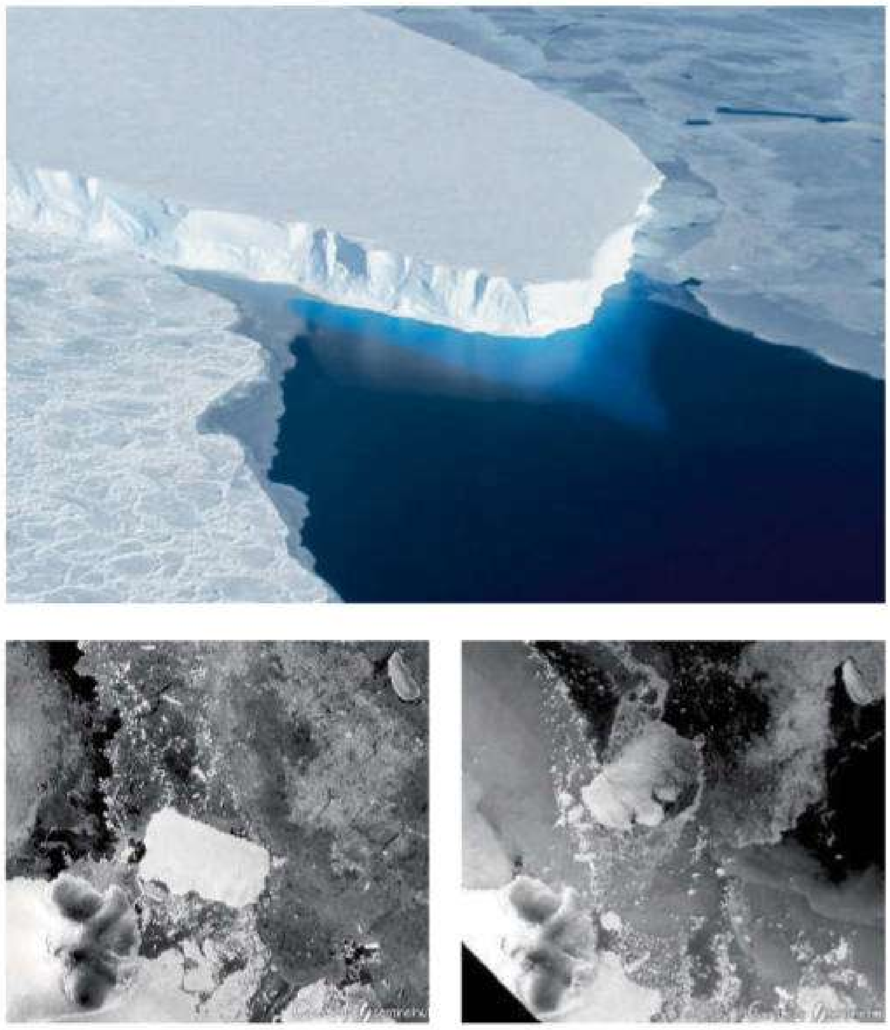
Those from unburnt areas were twice as alert to the sound of a hungry falcon – a natural predator of the species – as those from burnt areas. The results suggest lizards that survive fires perceive blazes as an even greater threat than an avian predator. ▮

Corryn Wetzel

Geoscience

Huge iceberg breaks away from 'doomsday glacier'

Michael Le Page



NASA

SIMON GASCOIN AT CNRS

Top: Thwaites glacier in West Antarctica. Below: Images of the B22A iceberg before (left) and after coming unstuck

A MASSIVE iceberg that got stuck and was helping to slow the loss of floating ice from the Thwaites glacier in West Antarctica has come free.

The iceberg, which started out roughly 85 kilometres in length and 64 kilometres wide, originally broke away from the floating ice shelf formed by the glacier in March 2002, but got caught in a shallow part of the Amundsen Sea around 100 kilometres away.

Its presence there had been helping to anchor sea ice – formed by the freezing of the sea in winter – in the area behind it, which, in turn, has helped to hold back icebergs and the remaining ice shelf in this area.

But in the past few months, it has finally come unstuck and is drifting off into the Southern Ocean, as the time-lapse satellite images (right) show.

"The iceberg was always going to unground and drift away at some point in time," says Bertie Miles at the University of Edinburgh in the UK. As a consequence, "we could see some more frequent break-outs of the icebergs in front of Thwaites", he says. The drifting away of B22A, as the iceberg is known, won't directly increase the discharge of Thwaites glacier or raise sea level, he says.

85km

Initial length of the B22A iceberg first seen in 2002

However, Antarctica is covered by ice sheets that are more than 2 kilometres thick on average. Some of this ice flows in glaciers to the sea, at which point it forms floating ice shelves up to a kilometre thick. These ice shelves act as dams, holding back the ice on land behind them. As a result of global warming, some ice shelves are starting to break up. This means the glaciers behind them are speeding up and pouring more ice into the sea, raising sea level worldwide.

The Thwaites glacier, dubbed the "doomsday glacier" for the potential domino effect should it collapse, holds enough water on its own to raise sea level by 65 centimetres and is already responsible for 4 per cent of current sea level rise. The collapse of the associated and much larger West Antarctic ice sheet would raise sea level by more than 3 metres.

The Thwaites glacier has already lost most of its ice shelf. Part of what remains is currently pinned in place by an undersea mountain, but it could soon break free.

"The ice shelf is heavily broken up already," says Miles. "The sea ice is acting a little bit like glue, sticking it together."

The glacier and its ice sheet are expected to collapse over the following centuries. They are unstable because they sit on land that is below sea level, and further inland that surface is deeper below sea level. What this means is that as the glacier retreats, more and more sea water can get under it, a positive feedback leading to accelerating retreat. "It's the one we're most concerned about," says Miles. ▮

Space

Our galaxy seems to be missing half of its regular matter

Leah Crane

THE Milky Way appears to be missing some of its matter. A study of a powerful flash of cosmic radio waves called a fast radio burst (FRB) has shown that the area in and around our home galaxy has less normal, or baryonic, matter than we would expect, as compared with the amount of dark matter.

The Deep Synoptic Array (DSA), a set of 110 radio dishes in California, of which 63 have been operating so far, was designed specifically to spot FRBs and trace them back to their home galaxies. In doing so, it can also be used to calculate the amount of matter between those galaxies and the detector by measuring how that matter has absorbed some of the radiation from the FRBs – a bit like shining a light through fog to determine how thick the fog is.

Vikram Ravi at the California Institute of Technology presented one such measurement on 9 January at a meeting of the American Astronomical Society in Seattle. He and his colleagues used the light from a burst called FRB 20220319D, which originated in a galaxy about 163 million light years away, to examine the matter in the Milky Way's halo – a spherical cloud of stars, gas and dark matter in which the galaxy's disc is embedded (arXiv, doi.org/grmmcc).

"Although the universe on average has something like 16 per cent baryonic matter, with the rest being dark matter, the baryon fraction of the Milky Way is much lower," said Ravi. The observations showed that the Milky Way's halo is made up of about 9.6 per cent baryonic matter at most, 40 per cent less than the universe at large. "It's surprising in the sense that, for a fair while – at least within the FRB community – we assumed that [galactic] halos kind of keep the cosmic fraction of baryons that we would expect," said Ravi. ▮

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Health

Wrinkles reduced by mRNA injections

USING mRNA to direct the body to make more collagen – the most abundant protein in skin – reduces wrinkles in mice.

Therapies that use mRNA give cells the genetic instructions to produce proteins. To test whether this could be used to replace lost collagen, Betty Kim at the MD Anderson Cancer Center in Texas and her colleagues injected mRNA into hairless mice that had been exposed to UV radiation for 60 days to trigger wrinkles. After 28 days, those injected with the mRNA had the same number of wrinkles, on average, as mice that hadn't been exposed to UV light (*Nature Biomedical Engineering*, doi.org/jsp2).

This effect wore off after four weeks, with wrinkles returning to pre-treatment levels after 56 days. **Grace Wade**

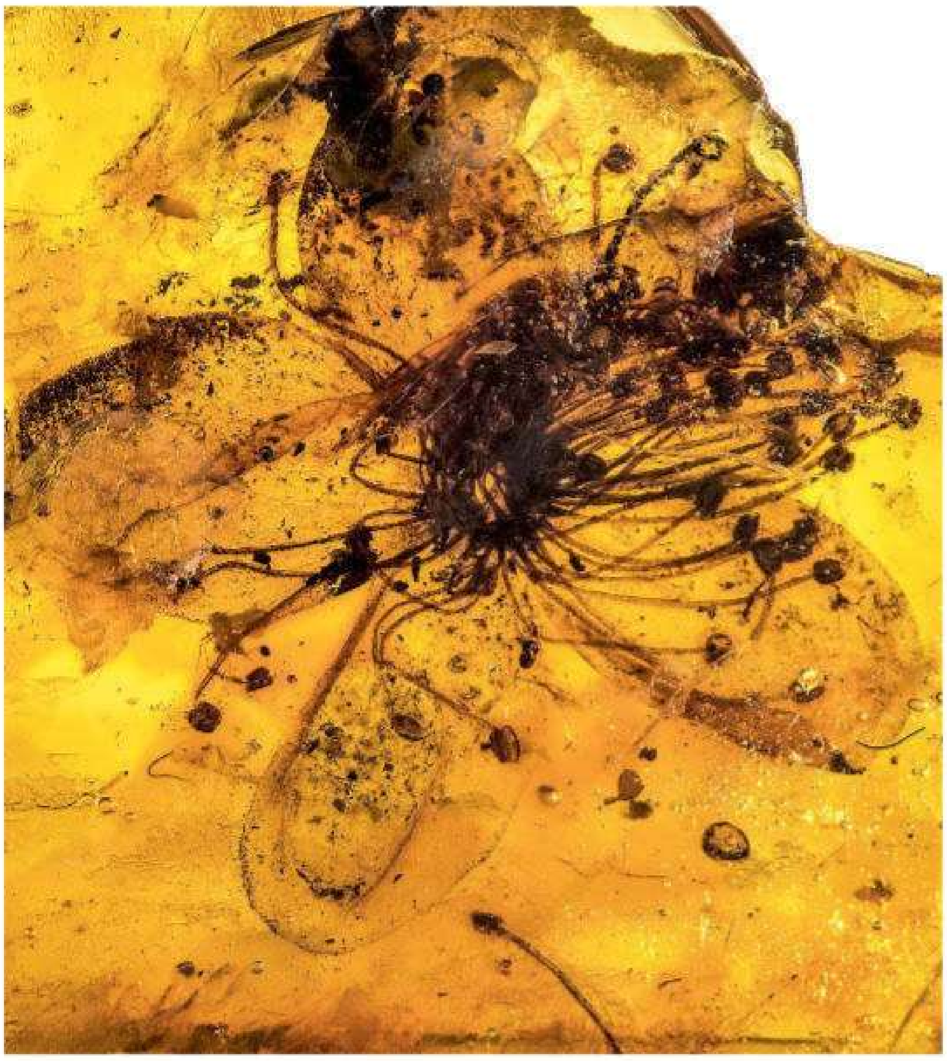
Health

Vaginal swabs could predict preterm birth

CERTAIN metabolic substances in the vagina during pregnancy may predict if a baby will be premature. Testing for these could help identify high-risk pregnancies.

Tal Korem at Columbia University in New York and his colleagues assessed 232 vaginal swab samples collected during the second trimester of pregnancy, 80 of which came from pregnancies ending in preterm birth. They identified both the microbes and the metabolites in each sample. Metabolites are small substances made when foods, drugs or other chemicals degrade.

The team then trained machine learning models to predict if a pregnancy would end in preterm birth and found that certain metabolites, but not microbes, had the strongest association with preterm birth (*Nature Microbiology*, doi.org/jsp3). **GW**



CAROLA RADKE, MFN

Palaeontology

Largest flower found frozen in amber is a new species

THE largest fossil of a flower in amber (pictured) has been described in detail 150 years after it was first studied – and it has been reclassified as a different species.

The fossilised flower was discovered and described in 1872, says Eva-Maria Sadowski at the Natural History Museum in Berlin, Germany. The five-petalled flower, which is about 28 millimetres in diameter, is encased in Baltic amber. It is nearly three times as large as other flower fossils found encased in amber, says Sadowski.

It isn't certain where the amber came from, but it was probably discovered in a mine in what is now Kaliningrad in Russia, she says. Amber deposits in the mine have previously been dated to between 33.9 million and 38 million years old, so the flower probably came from that period. The most likely amber source is a resin produced by conifer trees, says Sadowski.

Sadowski and Christa-Charlotte Hofmann at the University of Vienna in Austria reanalysed the fossil, focusing on its pollen, which hadn't been previously described. They found that the amber appears to have encased the flower just as it was releasing pollen.

The fossil was originally categorised as coming from a flowering evergreen plant called *Stewartia kowalewskii*. However, scanning electron microscopy of the pollen showed this was unlikely. Instead, it shared similarities with pollen from the modern flowering species of the *Symplocos* genus, but isn't from any known species that currently exists, says Sadowski. The pair have renamed the fossil *Symplocos kowalewskii* (*Scientific Reports*, doi.org/jspx). **Jason Arunn Murugesu**

Really brief

KILITO CHAN/GETTY IMAGES

Breathing exercises may boost mood

Cyclic sighing – inhaling slowly then taking another breath to fully inflate the lungs, before breathing out again slowly – seems to lift people's moods. This is according to a study of 114 people doing either meditation or breathing exercises every day for one month (*Cell Reports Medicine*, doi.org/jspt).

Lar gibbons sing duets together

Male and female lar gibbons (*Hylobates lar*) sing duets with notes that are synchronised and occur at regular intervals. These are rhythmic qualities similar to those in human songs, which could hint at an evolutionary basis for the origins of music (*Proceedings of the Royal Society B*, doi.org/jspw).

Oddly few stars in early galaxies

Some of the universe's earliest galaxies seem to have an order of magnitude fewer stars than previously thought, according to data from the James Webb Space Telescope. These stars, some of the first to form, also appear to be dimmer and bluer than previous telescopes indicated (arxiv.org/abs/2301.00027).

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Hospice UK**

hospice UK

Dying Matters, so why do we struggle to talk about it?

Talking about death, dying and bereavement is something that people can find intimidating. It can feel awkward or uncomfortable and sometimes, you just don't know what to say.

Led by the charity Hospice UK, Dying Matters is the campaign that's trying to change that. Our mission is to break the stigma, challenge preconceptions and normalise public openness around dying. And we find that when people do start the conversation, they rarely find it to be as scary as they thought.

We need everyone to be able to talk more about death and dying. The pandemic made that clearer than ever – and demographic trends mean more people are dying each year. We need to have open conversations between family and friends, colleagues, healthcare professionals, the media and politicians so we can challenge the taboo and support each other.

We know that millions of people like you believe in what we're trying to do. And so we're working with the public and with partners from across the cultural, arts, education and faith sectors to achieve it.

As those often at the forefront of dealing with it, we want to help those working in healthcare to talk more openly about death and grief. But other than those in specialist palliative care roles, most doctors, nurses and other healthcare professionals receive little to no support to do so. We want to make sure they have the right skills and training to look after patients nearing the end of their life and the right vocabulary and expertise to support their families.

We want to normalise conversations about grief in the workplace, too, creating a culture where compassionate managers and colleagues support their staff who are carers, support staff after death, and support grieving colleagues. Hospice UK's Compassionate Employers programme helps companies to do just that.

If you share our belief that talking more about dying is important, then join our community and we'll support you all the way.

Want to help?

Visit www.hospiceuk.org/dyingmatters to get involved and help us break the stigma, challenge preconceptions, and normalise discussion of death, dying, and bereavement.

Do you need your signal boosted?

If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

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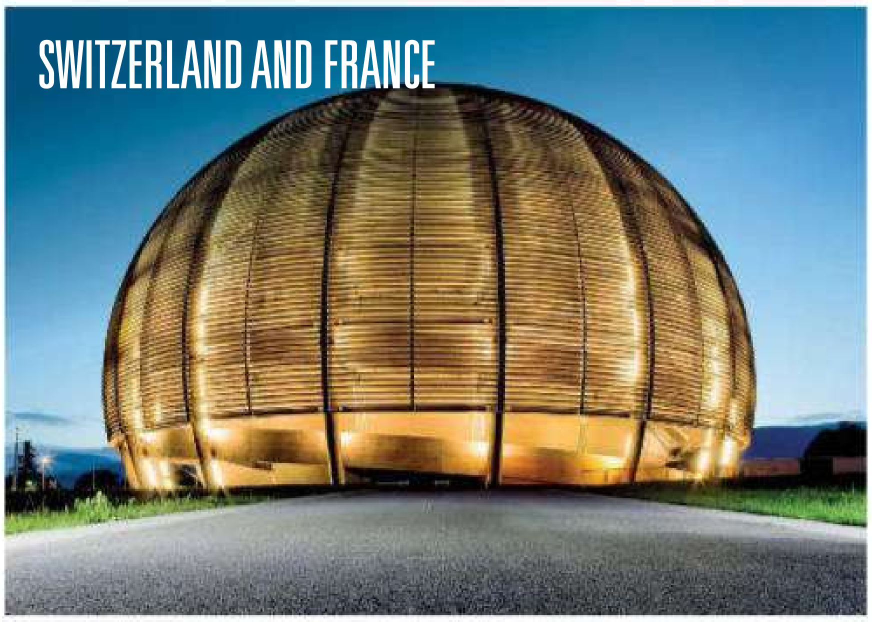

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Annalee Newitz gives a planet a starring role in their novel p28

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A new book changes minds about meditation p34

Culture columnist
Bethan Ackerley on *The Last of Us* and fungal horror p36

Comment

Time for a drink?

Most hospitals ban all drinks for 2 hours before surgery, but there is growing evidence these guidelines are out of date, says **Clare Wilson**

IF YOU have had surgery, you may have experienced an unpleasant aspect of it that happens even before you are wheeled into the operating theatre. People are usually told they must have nothing to drink – "nil by mouth" – for 2 hours before the surgery. But the 2-hour fluid fast tends to become longer, as operations are often delayed, meaning that people may go without anything to drink for several hours, sometimes even most of a day.

The good news is that things are changing. A new approach practised in a few hospitals around the world lets people continue drinking small amounts of water or other clear fluids until the point they are sent to theatre. Now, its advocates want to spread the word so more patients get the benefits.

MICHELLE D'URBANO

The strict fasting rules before surgery were introduced in the mid-20th century because occasionally, while anaesthetised, people regurgitate some of their stomach contents and this can pass into their airways.

If food blocks the airways, it can cause suffocation. Even if only liquid is aspirated, stomach acid can damage the delicate tissues of the lung. So anaesthetists decreed that people should have nothing to eat for at least 6 hours before surgery, as well as nothing to drink for the last 2 hours. This became part of hospital guidelines in the UK, US and many other countries.

But in the past decade there have been growing calls to liberalise the rules on fluids. The latest incarnation is to actually encourage people to consume up to one glass – of about 150 to 170 millilitres – per hour of clear fluids such as apple juice until their operation, in a policy that in Scotland is called Sip Til Send.

The liberalisers have several motivations. Firstly, it has become apparent just how long some people are going without drinking under the current rules, because of the way that scheduled operations are delayed to fit in emergency surgeries. One study of people having hip surgery found that more than half had gone 6 hours without fluids and more than a fifth had gone over 10 hours.

There is also growing awareness of the potential harms when people go into surgery seriously dehydrated. It not only makes them feel nauseous and miserable before and after the operation, but it can lead to worse medical outcomes, especially in those who are older or frail. Studies have suggested that a more liberal fluids policy cuts postoperative nausea and is linked with a lower chance of someone becoming delirious while recovering.

How about the risk from aspiration? It now seems this was overstated. More than half of people having emergency surgery have some food or liquids in their stomach, yet the number who aspirate anything is very low.

In any case, a Sip Til Send approach leads to little difference in the amount of liquid in the stomach, because clear liquids are emptied from the stomach very quickly. Ninewells Hospital and Medical School in the UK introduced Sip Til Send in 2021 and has seen no increase in aspirations. It has since helped more than 50 other hospitals in the UK, elsewhere in Europe and in Australia and New Zealand emulate this approach. US hospitals are usually more cautious about fasting rules.

It is understandable that medical staff may be reluctant to change something they have done for decades, especially when it contradicts safety guidelines. But it is past time for those guidelines to catch up with best practice, says an opinion piece in February's issue of *Anaesthesia*.

It may be that, in the future, doctors look back on the current rules as overly strict, akin to the way we used to forbid parents from staying with their children in hospital. When it comes to preoperative fasting, it seems to be time to rewrite the rulebooks. ■

Clare Wilson is a reporter at *New Scientist*. Follow her @ClareWilsonMed

This changes everything

If planets could talk My new novel looks at what it means when a planet becomes a character in the story. I spoke to some scientists to see how this might work, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
The Red Scholar's Wake *by Aliette Debodard, an action-packed story of the marriage between an engineer and a sentient pirate spaceship.*

What I'm watching
Avatar: The Way of Water, *which had a lot of flaws, but is still worth seeing.*

What I'm working on
Going on a book tour for The Terraformers*!*

This column appears monthly

IF YOU could build an Earth-like planet, what would you leave out of the design specs? That is the question I asked a handful of mildly amused scientists as I began to write my latest novel, *The Terraformers*.

It is the story of a group of construction experts who are working for a shady interplanetary real estate development company. Their mandate is to create a branded Pleistocene experience like that on palaeolithic Earth 15,000 years ago, for people in *Homo sapiens* bodies who crave that authentic Earth *je ne sais quoi*.

The thing is, if you are developing an Earth that is basically for tourists and Pleistocene fetishists, you would probably cut a few corners. You might make it just a little less dangerous than the original. But I wasn't sure what you would edit out, so I called up David Catling, a planetary scientist at the University of Washington and author of the intriguingly titled book *Atmospheric Evolution on Inhabited and Lifeless Worlds*.

I asked Catling what the ideal terraform-ready planet would be, assuming you wanted it to start out lifeless and turn into an Earth. To his credit, he seemed unfazed by my question. Once I had convinced him not to put it in orbit around a red dwarf (his preferred star), he said maybe it could be a planet around a yellow star whose atmosphere had been eroded by a catastrophic impact. "That's within the realm of possibility," he allowed.

My next burning question was how quickly an Earth-like atmosphere could be built. Put another way: how many generations of poor terraformers would live and die before they could breathe that sweet, sweet 21 per cent oxygen air?

Catling conceded that maybe you could get there in 10,000 years, as long as you had access to all kinds of technologies that don't exist yet. No problem – the novel takes place 60,000 years in the future, so we can assume all sorts of handwavium and unobtainium are there to make this work.

Next, I got into how the terraformed planet's crust would work. Attreyee Ghosh, a geophysicist at the Indian Institute of Science in Bangalore, assured me that nobody with a choice in the matter would ever build a civilisation on a planet with plate tectonics.

> **"Nobody with a choice in the matter would ever build a civilisation on a planet with plate tectonics"**

She would know: she has devoted her life to studying how plate tectonics work. Our planet's crust is broken into plates that are constantly moving around on top of a layer of magma, creating unpredictable quakes and tsunamis, plus the occasional unexpected volcano.

Still, having watched what happens when engineers get excited, I could imagine them installing a system to cause plate tectonics – and then, at the last minute, the marketing people telling them not to activate it. Ghosh helped me devise a planet-spanning device that could jump-start plate tectonics. Luckily for all those real estate buyers, this machine has been completely shut down and could never possibly harm anyone. Yep. Everything is totally safe.

To bring this planet to life, though, I needed ecosystems that were a reasonable facsimile of Pleistocene Earth habitats. But how would a real estate corporation build ecosystems so that they could be maintained with the least amount of effort?

Obviously, they would design every living thing to be part of a worldwide surveillance network. So my planet is packed with tiny, biodegradable sensors that can live inside cells or cling to a speck of dust – and all of them are networked. Christine Payne, a materials scientist at Duke University in North Carolina, described to me how sensors could be made from paper and other materials that would fully integrate into biological systems.

Every part of my planet can actually "talk" to the terraformers building it. Grass can describe the nitrogen content of soil and the soil itself can describe erosion processes. Some of my characters can connect to the planet's sensor network, allowing them to feel the wind in the trees or sense when an ecosystem is producing too much carbon.

Non-human animals can also speak. Characters who are moose, cats, cows and naked mole rats have their own opinions about what they would like the planet to become. The sensor network ultimately lets everyone understand, innately, their relationship to the environment. When an ecosystem is out of balance, they feel it in their bodies.

For me, writing science fiction is about explaining where real-life science and technology might plausibly take us, then planting a wish inside it. Maybe, one day, our planets will tell us how they want to be treated. My wish is for us to make a bargain with them, where we agree to sustain each other's lives. ▮

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Zooming in

Photographer Julian Abrams

WITHOUT them, we would scarcely be able to comprehend the universe. Telescopes, whose majesty and complexity have been captured in these images by photographer Julian Abrams, are among astronomy's most crucial instruments. They have opened our eyes to everything from the weather on distant planets to the workings of gravity.

The shots are from *Everything Beautiful Is Far Away*, a project by Abrams in collaboration with astronomer Richard Ellis at University College London. It pays homage to the major telescopes of the world and their impressive housings.

These are structures that "would not look out of place on the harsh and dramatic fictional landscape of Tatooine", writes Abrams in the accompanying book. "Standing as paeans to human achievement… these detached and futuristic masterpieces exist solely to serve their scientific function."

Clockwise from top left, the images show: the Very Large Telescope in the Atacama desert, Chile, which is a complex of four instruments, each more than 8 metres across; the Anglo-Australian Telescope in New South Wales, Australia; the Cassegrain focus – effectively the lens – of the Subaru Telescope atop the Mauna Kea volcano in Hawaii; hexagonal mirror segments (needed to gather light to resolve distant objects) being prepared for one of the two Keck telescopes, also at Mauna Kea; and a computer monitor for the Isaac Newton Telescope at the Roque de los Muchachos Observatory in the Canary Islands, Spain, the oldest of the 20 telescopes on that site. ▮

Gege Li

Editor's pick

Science plus art is a potent mixture to be encouraged

7 January, p 21

From Ros Groves, Watford, Hertfordshire, UK

Danielle Olsen is absolutely right in advocating that the arts should go hand in hand with science. The popular and much misguided tendency is to see the two as mutually exclusive, with the arts often dismissed as a mere frivolity.

While the arts may provide a different type of stimulus for the brain, it is one that doubtlessly complements its more logical counterpart by providing freedom of thought, relatively unrestrained by accepted rules – that is, an ability to think outside the box.

Imagination, inspiration and inventiveness have proved to be valuable not only in conjunction with the treatment of mental health conditions, but also as the basis of many scientific discoveries previously deemed implausible due to the existing limits of knowledge.

Albert Einstein was an accomplished musician who regarded music as intrinsic to his scientific work. Faced with a physics conundrum, he would adjourn to the piano or the violin before returning to his work, seeing the creative stimulation of music as having inspired the solution.

Alien messages could be written in meteorites

17/24 December 2022, p 64, p 66

From Alan Wells, Saltdean, East Sussex, UK

Abigail Beall rightly questions what we are trying to say to aliens, either via radio signals or with artefacts on space probes.

Meanwhile, at the end of Becca Caddy's interesting article on digital storage, she mentions using lasers to encode data into silica glass by creating data-dense nanostructures that a microscope can read, creating a virtually eternal data storage system.

Imagine ourselves in 50 to 100 years' time, a spacefaring species still dependent on a dying planet: might we not consider storing all our knowledge on such silica "rocks" to serve as a warning to alien life forms, as well as to give them technologies that could avoid their own downfall? We could launch suitable vehicles to exoplanets to scatter the rocks.

Putting the boot on the other foot, perhaps a doomed alien species would similarly target such rocks at worlds beyond their planetary system, including Earth? Maybe careful examination of anomalous meteorites could yield some interesting information?

Plenty of nitrogenous waste is going to waste

31 December 2022, p 16

From Guy Cox, Sydney, Australia

You report a plan to produce environmentally friendly food from bacteria using only green hydrogen, carbon dioxide and ammonia. The ammonia in this recipe will almost certainly be produced by means of the Haber-Bosch process, which is a major source of CO_2 emissions.

The odd thing is that each of us excretes a nearly pure solution of nitrogen-rich urea every day, and we just flush it away. If we changed our plumbing to make use of it, we could pretty much eliminate our dependence on the Haber-Bosch process.

For blind people like me, melatonin seems to work

31 December 2022, p 41

From Tom Reid, London, UK

When it comes to the efficacy – or not – of melatonin for sleep, one group that got no mention is totally blind people.

Random trials are hard to come by, as we are such a small group, but I know several blind people who say that melatonin makes a significant difference to sleep.

For years, I had poor sleep, sometimes only 2 or 3 hours per night. This was unrelated to mood, whether life was going well or not, and no behavioural changes made a difference. With melatonin, my sleep has increased by hours, I am able to nod off after waking and have more dreams. If I have tricked myself, long live the placebo.

Try spotting the mega spaceship drive instead

17/24 December 2022, p 9

From Andrew Ward, Wotton-under-Edge, Gloucestershire, UK

If aliens are flying Jupiter-mass spacecraft around the galaxy, surely we are more likely to detect the effects of the drive required to accelerate and decelerate such a large mass – which is likely to travel at a significant fraction of the speed of light – rather than the minuscule ripples in space-time generated by the moving craft?

Perhaps the fleeting alignment of such a spaceship drive with our telescopes explains something that we have already observed: gamma-ray bursts.

Let's turn a lot more data into sound

31 December 2022, p 46

From David Muir, Edinburgh, UK

You report that the use of sonification in astronomy to turn data into audio has led to surprising discoveries. Surely other scientific fields with vast quantities of data to be analysed, sometimes urgently, could benefit from the use of sonification.

Areas that jump to my mind are volcanology, MRI and CT scans seismology, criminology and the detection of flaws in pipes.

As your article states, for noisy and multidimensional data sets, sonification provides a chance for human input to help identify interesting features, as well as to discern the significance of outliers and anomalies. There must be umpteen disciplines where this could improve analysis.

Is animal personality enough for personhood?

7 January, p 30

From Gerard Buzolic, Coolum Beach, Queensland, Australia

Annalee Newitz's new novel, *The Terraformers*, reviewed by Sally Adee, raises the issue of how we assign the quality of personhood to non-humans.

Pet owners and animal lovers know that animals have personalities. I scatter birdseed each morning and enjoy seeing the doves and pigeons take it. There is something in a tilt of the head to show curiosity, or in the raising of an eyebrow, that is very human. They make one suspect there is more going on in those small heads than meets the eye.

Perhaps it isn't so much intelligence as personality that should make us ascribe personhood to animals.

Dig for climate victory in the central Asian region

7 January, p 38

From Mike Bell, Woolacombe, Devon, UK

You pondered solutions to save the world, including building a sunshade in space to confront global warming. I have another geoengineering idea. A canal dug between the Black Sea and the Caspian Sea would provide central Asian countries with access to global shipping and increase precipitation in the region. The extra rain would enable carbon-sequestering forests to grow and maybe help refill the Aral Sea. ■

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The inner challenge

Meditation seems to divide people into converts and questioners. Former sceptic **Jonathan R. Goodman** discovers a book that changes his mind

Book
Why We Meditate
Daniel Goleman and Tsoknyi Rinpoche
Penguin Life

TAMER ALKIS/ISTOCKPHOTO/GETTY IMAGES

Meditation seems to reduce stress and the risk of certain ailments

I OPENED Daniel Goleman and Tsoknyi Rinpoche's *Why We Meditate: 7 simple practices for a calmer mind* with some scepticism. I am not a regular meditator, and while I have read a few popular books that aim to convince you of its usefulness, I have never been convinced. Questions like "How can I relax and stay focused on work?" and "Isn't some stress necessary for living during angsty times?" prevented me from accepting meditation as a legitimate way of dealing with stress and life.

But Goleman and Rinpoche, a science writer-psychologist and Buddhist teacher respectively, have done something different in their book. They come armed with responses to these questions, knowing that their readers are likely to have these concerns. Rinpoche writes about how calmness doesn't need to interfere with alertness; Goleman testifies that he balances his busy work life with regular meditation practice.

In spite of my scepticism – and the fact that I was reading this book for review, not by choice – I felt myself more and more taken with its arguments. Thoughts about how my own stressors interfere with my concentration emerged throughout the day. I realised over the following weeks that the methods Goleman and Rinpoche offer are worth thinking about, not only because they might help me through stressful times, but because they might enable us all to become more compassionate generally.

Rinpoche talks a great deal about the history of meditation and how, within its many schools of thought, love and compassion are notions we ought to champion. We need to learn – through consistent and quiet engagement with our bodies, feelings and minds – to love ourselves, and in doing so we can learn to love others.

> **"Each chapter is a kind of antidote for the scepticism I think many people feel about meditation"**

This is underlined when Rinpoche describes feeling drawn by an advert to buy a computer, which brought temporary relief from a hollowness that was plaguing him. Similar feelings drive so many of our behaviours, but the authors think this can be filled only through self-understanding, not consumption.

Goleman backs up many of Rinpoche's discussions of meditation with evidence from the psychological and medical sciences. Only recently, Goleman writes, have researchers integrated meditation practices that originate in Asia with clinical psychology, with positive results. The medical benefits appear extraordinary, too: people who meditate have less physiological and genetic evidence of stress, and seem at a lower risk for a variety of ailments.

Each chapter is a kind of antidote for the scepticism I think many people feel about meditation. Rinpoche shows you that meditation isn't just some smug self-help practice that isn't compatible with the busyness of modern life, which he has experienced himself. Goleman shows that the practices Rinpoche describes don't just bring short-term cognitive benefits. Together, the pair give valid reasons to meditate, ones that sceptical rationalists can't just ignore.

At times, though, the science doesn't always seem sound. Goleman talks about our evolutionary history in an unconvincing way. Anxiety isn't, as I think he assumes, just a maladapted version of the fight-or-flight response, for example. Social pressures have always been integral to being human. We don't just worry about our social and work lives at 3am because of some evolutionary hangover – we stress because society is stressful.

For me, the amygdala region of the brain (dealing with decision-making, memory-making and emotional responses) features too often in the science sections of the book. In fact, referring to the amygdala started to feel more like a mantra than scientific justification for meditation.

And yet I find myself convinced by much of what both Rinpoche and Goleman say. In the final chapter, they suggest that readers commit to regular meditation. As a former sceptic, I am happy to say I will do so – and to recommend that you read this book. ▮

Jonathan R. Goodman is at the Leverhulme Centre for Human Evolutionary Studies in the UK

The flames within

A fascinating primer explores the crucial role of inflammation in our bodies and how it can go awry, finds **Grace Wade**

Book

A Silent Fire

Shilpa Ravella

Bodley Head

INFLAMMATION is a crucial tool of the immune system. As the body's first line of defence against injury or invaders, it traps bacteria and viruses, heals wounds and signals to other cells for help, resulting in symptoms such as pain and swelling. Once a threat is remedied, inflammation, along with its ensuing discomfort, disappears – or at least it should.

In her debut book *A Silent Fire: The story of inflammation, diet and disease*, gastroenterologist Shilpa Ravella explains how inflammatory responses can turn against us. Crucially, she shows how chronic inflammation plays a role in many common conditions, such as diabetes, heart disease and cancer, and why Western diets are at least partially to blame.

This primer sees Ravella start with some fascinating history, travelling all the way back to the 1st century, when Aulus Cornelius Celsus first described four of the five main signs of inflammation: pain, heat, redness and swelling. The fifth, a loss of function, was identified in the mid-1800s.

Ravella spends a lot of time with Victorian scientists, such as Élie (Ilya) Metchnikoff, who won a Nobel prize in 1908 for discovering immune cells called phagocytes that engulf pathogens and particles. Eventually, she moves on to modern-day researchers like Charles Serhan, who helped identify molecules known as resolvins that turn off inflammation.

This lays a proper foundation for the book's second section, which connects these discoveries to inflammation's possible role in disease. Low levels of inflammation have been found in people with conditions such as cancer. While inflammation is a normal response to injury and disease, persistent inflammation is now being viewed as a potential cause of illness.

Ravella speculates that inflammation can contribute to conditions like depression (see page 38) and Alzheimer's disease, though as a responsible medical professional, she provides important caveats and stresses the need for more research.

The most damning evidence links inflammation to autoimmune conditions – which occur when the body damages its own cells – such as rheumatoid arthritis. Characterised by long-lasting, low levels of inflammation, these conditions increase susceptibility to other problems like bone loss, heart disease and kidney disease.

The book wraps up by detailing how factors like diet and exercise can contribute to inflammation as well as help dampen it. For many, this won't be new, but what may be illuminating is Ravella's explanation of lifestyle's significance.

For instance, she devotes a whole chapter to the gut microbiome, describing how processed foods and animal products, like red meat and dairy, disrupt microbial composition, setting off a chain of events that leads to increased inflammation. She then explains why fruits, vegetables and whole grains can help undo these effects.

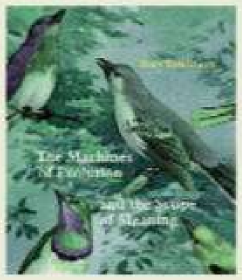
A Silent Fire is no quick read: it is packed with information, combining medical history, innovative research and first-hand clinical experiences. At times, it feels over-ambitious, as Ravella crams in as much as possible rather than clearly connecting the various topics. It can also be difficult to keep track of all the different microbes, scientists and immune cells involved, especially if you lack a scientific or medical background.

But Ravella's writing style keeps even the most dense page engaging. She breathes life into biological functions, at one point describing types of white blood cells as "sophisticated warriors" that "voraciously gobble up" particles. Ultimately, the book is perfect for those looking to delve deeper into the history and intricate workings of immunology, diet and disease. ▮

Rheumatoid arthritis, as shown in this X-ray, is a chronic inflammatory condition

SPL

Don't miss



Read

The Machines of Evolution and the Scope of Meaning by Gary Tomlinson explores the evolution of information and meaning from microbes to humans. On sale from 14 February in the US and 21 March in the UK.

Watch

Is Wildlife Crime a Security Threat? asks political ecologist Rosaleen Duffy, as she considers the new role of private military firms, intelligence services, risk analysts and drone makers in conservation. See it online at 6pm GMT on 26 January.

Watch

Rapid Motion Through Space from the Cosmic Shambles Network is its first feature-length documentary. Tackling speed, it includes hordes of snails. Premieres at the Royal Institution in London at 7pm GMT on 27 January.

DR LAURE JOANNY

The TV column

Rise of the killer fungi A deadly *Cordyceps* fungus is key to the plot of *The Last of Us*, a hit video game adapted into a TV show. From *Hannibal* to *Whitechapel*, such fungi often steal the show as villains. What is going on, asks **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

TV
The Last of Us
Streaming now on HBO Max

HBO/WARNER MEDIA

Ellie (Bella Ramsey) and Joel (Pedro Pascal) in a US where fungi threaten

MY FAVOURITE fungus has a nasty party trick. *Ophiocordyceps unilateralis* is a parasite that bends the minds of insects to its will. After taking over an ant's central nervous system, it manipulates the insect into climbing up a plant to a spot with ideal conditions for the fungus to proliferate. While its muscles atrophy and its insides are consumed, the ant clamps its jaws in a "death grip" that firmly secures it to the plant, ensuring the parasite can continue to grow even after the insect perishes.

During the opening scene of *The Last of Us*, an excellent adaptation of the bestselling video game, a scientist in 1968 explains just how dangerous a pandemic driven by such a fungus could be, should it adapt to survive in the warmth of human bodies. Thirty-five years later, a *Cordyceps* fungus does just that, turning people into hyper-aggressive cannibals. By the time the show's protagonists Joel and Ellie start travelling across the US in 2023, *Cordyceps* is an ever-present threat, mottled over buildings and marbled through the decaying flesh of the infected.

The Last of Us may be the finest example of fungal horror to reach the small screen. This fascinating subgenre relies on a widespread mistrust of mushrooms and their kin. It is a fear, however misapplied, that is rooted in the powerful, often dangerous abilities of fungi, which some TV shows exploit to great effect.

> **"The point isn't that all fungi deserve their killer rep, but that horror thrives where there is ignorance"**

Take *The X-Files*. In the episode "Field Trip", agents Mulder and Scully stumble across a huge fungal growth. The hallucinogenic mushroom eventually renders its victims comatose, ready to be digested without a fight. There are many real-life fungi with similar hunting methods: for example, the oyster mushrooms you may eat for supper prey on nematode worms by paralysing them before turning them into slurry.

The mind-altering effects of mushrooms have historically been linked to fears of the supernatural. Several 17th-century witch trials may have their roots in ergotism, a form of poisoning caused by ergot fungi, which infect grains. Ingesting the infected crops leads to seizures, gangrene, paranoia, hallucinations and more.

This idea was explored in the fourth season of *Whitechapel*, a modern police procedural series inspired by historical murders, in which a serial killer who believes he is hunting down witches is actually experiencing ergotism.

It isn't just the poisonous effects of fungi that terrify, but their apparent intelligence. Mycelia – underground fungal structures of branching, root-like filaments – provide nutrients for fungi and act as complex networks.

Mycelia feature in *Hannibal*, a prequel series to *The Silence of the Lambs*, which follows Hannibal Lecter before his imprisonment, working with the FBI to profile serial killers. Pharmacist Eldon Stammets is one such killer. He induces diabetic comas in his patients, using their living bodies to grow mushrooms. His rationale is based on a belief that mycelia are sentient, grasping for connections that his decaying victims can supply and even crave themselves.

By referencing these televisual gems, my point isn't that all fungi deserve their killer rep, but that horror thrives where there is ignorance. We know little about fungi compared with animals and plants, and struggle to contain them within the same taxonomy. *Cordyceps*' effects are horrific in *The Last of Us*, but the show is careful to show that there are far greater things to fear than fungi. ▮

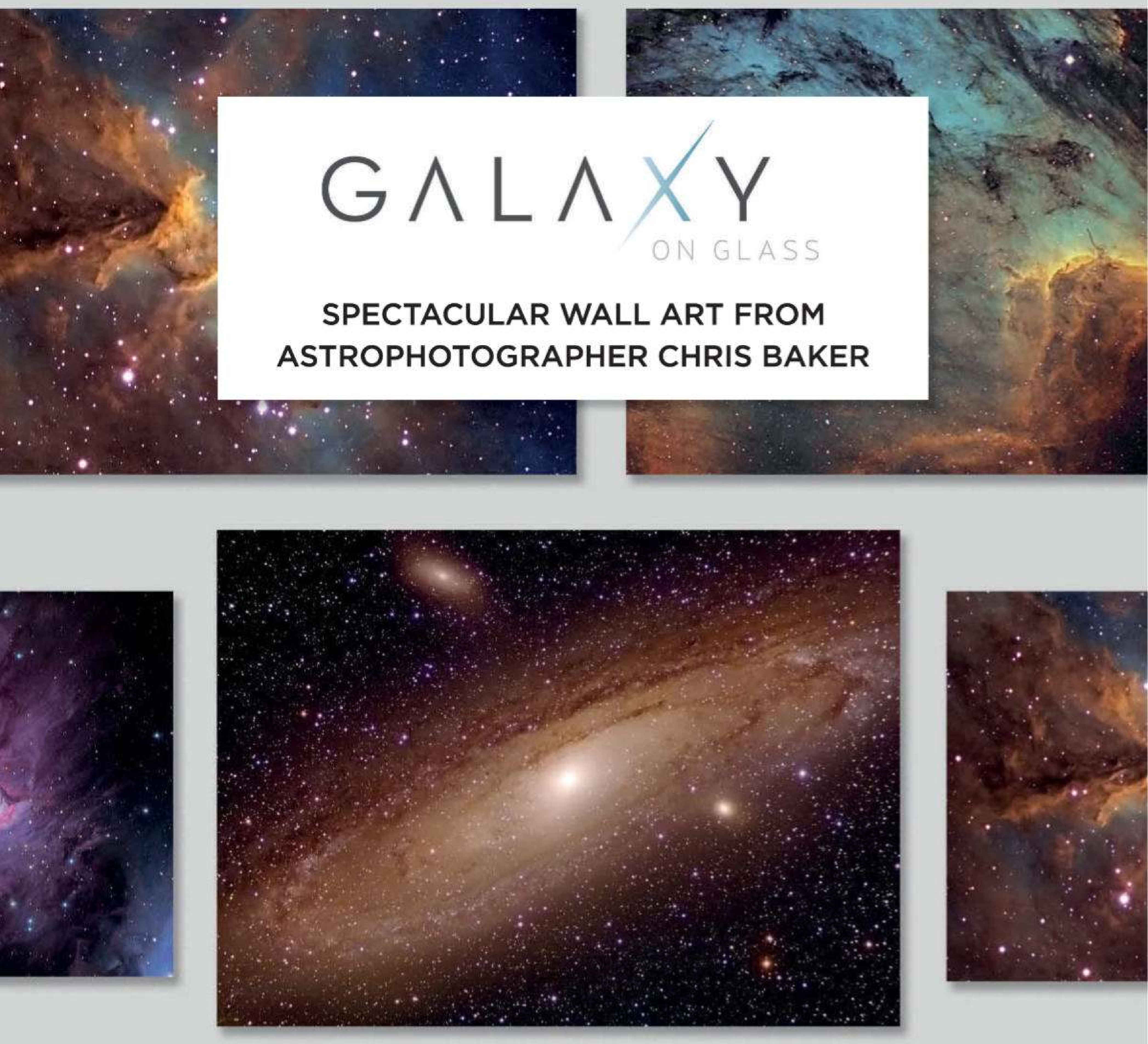
Bethan also recommends...

TV
Hannibal
NBC

One of the most beautiful TV shows of all time – no mean feat, given that grisly tableaux of dismemberment are to Hannibal what amnesia is to soap operas. Series developer Bryan Fuller serves up three seasons of baroque slaughter.

Whitechapel
ITV

Joseph Chandler and his team investigate copycat killers inspired by Jack the Ripper, the Kray twins and other historical ne'er-do-wells.



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Rethinking depression

We have totally misunderstood what causes depression. But, surprisingly, the search for treatments is making good progress, finds **Clare Wilson**

LAST year, one of our most commonly held ideas about depression was turned upside down. "Antidepressants study casts doubt on drugs taken by 8m people," *The Times* newspaper stated in July. Other publications ran similarly alarming headlines. Depression is one of the biggest medical problems facing societies worldwide, treatments have long been controversial and here was research showing that Prozac and other common antidepressants are based on a defunct hypothesis about what causes the condition. The study's lead researcher even went as far as to suggest that any benefits from such medicines come from a placebo effect.

Most antidepressant drugs are said to work by restoring levels of a brain-signalling chemical called serotonin, an idea sometimes known as the "chemical imbalance" hypothesis of depression. But the study found that, contrary to what we have been told for decades, depression isn't actually caused by low serotonin. This was a kick in the teeth for the many people who feel they depend on antidepressants. It also raises a key question: if low serotonin can't explain depression, then what can? That isn't the only mystery concerning the condition. We also don't know how talking or electroconvulsive therapies work, nor do we understand the impact of genetics or stress on mental health.

Yet, despite all this uncertainty, some surprising progress is being made. Two new treatments have recently become available and others in the pipeline show promise. "The level of science is more advanced than this paper implies," says Carmine Pariante at King's College London. "Things are not as bleak as they appear."

The two core features of depression are low mood and a lack of ability to take pleasure from usual activities. It is often accompanied by a range of physical symptoms, such as appetite loss, fatigue and insomnia. "It's a feeling of

GIULIA NERI

being tired and defeated – not wanting to be here," says Rachel Roodhardt, a children's author based in Folkestone, UK, who has been taking antidepressants for two decades. The idea that this is caused by a chemical imbalance in the brain arose in the 1960s, after a low blood pressure treatment was found to trigger low mood in some people. The drug, it turned out, reduces serotonin as well as two other brain chemicals, noradrenaline and dopamine. Antidepressants were then developed that raised one, two or all three of these substances. One of the first was Prozac, which blocks removal of serotonin from synapses, the junctions between brain cells – hence its description as a selective serotonin reuptake inhibitor, or SSRI.

The rise of Prozac

The great commercial success of Prozac in the 1990s cemented serotonin's reputation as the "feel-good chemical". That idea was bolstered by genetic evidence from the late 1990s, suggesting that people with depression are more likely to have a gene variant that produces a more efficient version of an enzyme that removes serotonin from synapses – the same enzyme that is blocked by SSRIs. Unfortunately, not all the facts fit neatly into this narrative. As genetic sequencing capabilities expanded and larger, more rigorous studies were carried out, it emerged that our innate propensity to depression is governed not by one gene, but by more than 100. Embarrassingly, the gene responsible for the serotonin-removing enzyme isn't even one of them. The consensus now is that it has nothing to do with depression risk.

Another blow to the serotonin story came from several large reanalyses of all the clinical trial data on antidepressants. Even in the late 1990s, these showed that the difference between the effects of the medicines and placebo is tiny. This is why, after last year's landmark study was published, its lead author, Joanna Moncrieff at University College London, stated that antidepressants may be just a form of placebo.

The main focus of Moncrieff and her colleagues' paper, however, was the lack of evidence to support the chemical imbalance hypothesis. It is hard to measure serotonin in the brain, but we can measure levels in cerebrospinal fluid of a compound it is broken down into. As the team reported, most studies don't see lower levels of this compound in people with depression. The findings came as no surprise to psychiatrists. For some years, the website of the UK's Royal College of Psychiatrists has stated that the chemical imbalance theory of depression is simplistic.

Nevertheless, some people who take antidepressants found the press coverage disturbing. "I felt like everything I've been told over the years is wrong," says Roodhardt. She is now in the process of reducing her dose with the help of her doctor, triggered partly by Moncrieff's analysis. On the other hand, Polly Arrowsmith, a small business owner in London, doesn't care how antidepressants work. "They make me feel a lot weller and happier and keep my mood stable. I expect to be on them for life," she says.

People shouldn't conclude that antidepressants don't work, says Pariante. The consensus among doctors is that, while they are no panacea, they can offer real help. Although, on average, the effects are only a little more than that seen with placebo tablets, this hides the fact that some people improve quite a lot, while others get no benefit, says Pariante. And those who aren't helped by the first drug they try may be by the second or third. "The level of evidence on antidepressant efficacy is overwhelming," he says.

What's more, there are still reasons to think serotonin is involved in depression › somehow. For instance, if you artificially lower serotonin in people who have previously been depressed, it can trigger temporary low mood. There is also no doubt that SSRIs quickly raise serotonin levels within synapses. Perhaps this brings about further downstream changes in the brain that help alleviate depression, even if low levels of that neurotransmitter weren't the initial trigger for symptoms, says Pariante. "Antidepressants could still change the function of the brain by changing serotonin."

Inflamed brains

All of which raises the question: if not chemical imbalance, what else could be behind depression? One idea is that it is caused by inflammation, a mild activation of the immune system. We usually notice inflammation if we injure ourselves: damaged cells release chemicals that trigger a cascade of immune system activity at the site of injury to kill any invading microbes. The resulting swelling and pain makes us rest the injured part of the body. Inflammation can also be "systemic" if there are raised levels of inflammatory chemicals circulating in the blood. Animals injected with certain of these compounds show "sickness behaviour", meaning they stay huddled in a corner of their cage. It is as if systemic inflammation leads to an urge to rest and protect the whole body.

With depression, the idea is that there may be slightly higher levels of activity of immune cells in the blood, and that inflammatory chemicals reach the brain. Certainly, some people with depression have higher levels of particular immune chemicals, such as one called C-reactive protein, or CRP. Intriguingly, some SSRIs and other antidepressant medicines seem to suppress inflammation.

It is too soon to pin all our hopes on inflammation, though. Only about 1 in 3 people who are depressed have higher CRP levels, says Edward Bullmore at the University of Cambridge, who has written a book on the subject called *The Inflamed Mind*. Nevertheless, those people could potentially benefit from anti-inflammatory medicines already in use for other illnesses. So far, trials of such drugs in depression have given mixed results. But no studies have yet recruited only people with high CRP levels, which would be the key test. "You want a trial where you put an anti-inflammatory drug into people who

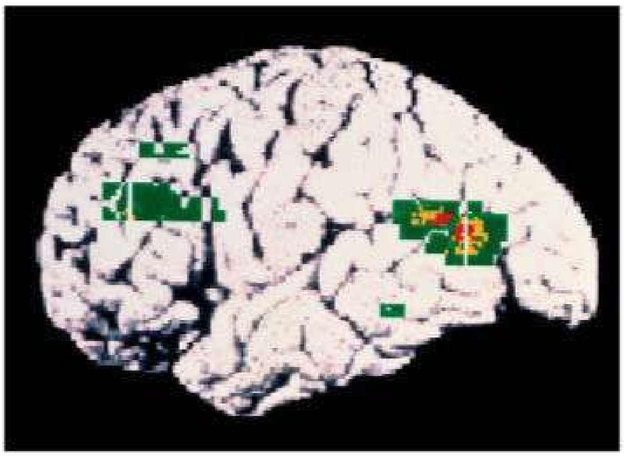
"A lack of neuroplasticity is another explanation for depression" have depression and inflammation, and it is antidepressant for them," says Bullmore.

An even more fruitful avenue of research involves ketamine, an anaesthetic that is also sometimes used recreationally. Like SSRIs, it affects signalling by a neurotransmitter, but a different one, called glutamate. "Glutamate is the single most common signalling mechanism in the brain," says John Krystal at Yale University. His idea to test ketamine as an antidepressant came from work showing that other drugs that bind to the normal receptors for glutamate seemed to reduce low mood in animals. Trials in people showed that an infusion of ketamine acts quickly to reduce depression symptoms. Most people then need repeat treatments every one or two weeks.

Ketamine is usually delivered in a drip and is only available from a few specialist clinics that are willing to prescribe it for a use different to that described in its licence. But wider uptake may be possible using a form of ketamine called esketamine that is squirted up the nose. This was approved for use in the US in 2019. However, it isn't available through the National Health Service in the UK. In August 2022, another antidepressant that binds to the glutamate receptor was approved in the US, this time one in tablet form called Auvelity.

It is too soon to say how many people this new type of antidepressant will help. Some psychiatrists fear people will become addicted because this can happen to those who take ketamine recreationally. But does the fact that these drugs work at all tell us anything useful? Frustratingly, as with SSRIs, ketamine's mechanism isn't clear. Its rapid effects, which occur in the first few hours after taking the drug, seem to stem from it binding to the glutamate receptor. But animal studies suggest that it also has longer-lasting impacts on brain chemistry, including boosting the release of a compound called brain-derived neurotrophic factor, or BDNF, which helps brain cells grow branches and make new synapses in response to learning, a process known as neuroplasticity.

A lack of neuroplasticity has been proposed as another underlying explanation for depression. The idea is that long-term stress leads to a reduction in BDNF levels, which reduces neuroplasticity. This triggers a vicious circle where impaired learning means people get stuck in unhelpful behaviour patterns, such as ruminating about upsetting or sad memories. Supporting this hypothesis, some animal studies have suggested that rodents in stressful environments have fewer neuron branches and synapses in their brain's cortex – and that taking ketamine can reverse this.


WELLCOME CENTRE HUMAN NEUROIMAGING/SPL

Depression can't be seen on a brain scan as was once thought

Other work in animals suggests that SSRIs also promote neuroplasticity. So does electroconvulsive therapy, in which an electric current is applied to the brain – a treatment reserved for people with the severest forms of depression. Although most of these findings come from work in animals, some studies have shown that SSRIs improve people's learning abilities in laboratory tasks. It still doesn't explain, though, why some people are helped by SSRIs but others aren't.

Psychedelic therapy

Even some talking therapies could fit with the neuroplasticity explanation. Cognitive behavioural therapy, for instance, explicitly encourages people to learn new patterns of behaviour in response to stressful situations and to unlearn harmful ones. This would explain why medications and talking therapies often work best together: the antidepressants make the brain more neuroplastic, while the person learns more helpful thought patterns.

Psychedelic drugs, such as psilocybin from magic mushrooms, have shown some signs of success against depression in small, early-stage trials in humans – and they seem to trigger neuroplasticity, too, at least in animals. They also directly stimulate one subtype of serotonin receptor, as well as causing a rise in dopamine levels. So these drugs seem to have multiple effects and it is unclear which one is most important. That doesn't concern everyone. "As a clinician, I'm not too bothered about how things work – more if they work," says James Rucker at King's College London, who is helping to test a synthetic form of psilocybin.

So, is neuroplasticity the new grand theory of depression? Pariante thinks not. Instead, he sees depression as a complex state that represents disturbances in multiple brain chemicals and neural circuits, with different aspects predominating in different people. That would explain why various treatments help some people, but not others. "You have multiple steps where you can intervene," he says. But it also means we need tests – or "biomarkers" – to identify which drugs and therapies are most appropriate for individuals. Already, blood tests for inflammation are being investigated as a way to guide psychiatrists' choice of antidepressants and whether to combine them with anti-inflammatory drugs. Other biomarkers may come from electroencephalograms or brain scans, as well as smartphone data tracking behaviour.

The US National Institute of Mental Health, which is one of the biggest funders of mental health research in the world, is planning trials that pit these different biomarker tests against each other. "We are asking investigators to take ideas that have good academic evidence and put them through the wringer," says Joshua Gordon, director of the institute. "I think we can do better with the treatments we have now, without understanding mechanisms."

This may not be much comfort for anyone currently struggling with depression. At the moment, doctors tend to offer a succession of drugs in a trial-and-error process, and it can take up to two months to check whether or not each treatment works. But in the future, biomarkers could be used to diagnose people with subtypes of depression that are most responsive to certain treatments. And doctors will be spoiled for choice if some of the promising experimental drugs reach the clinic. "There may be no such thing as the 'ultimate biological mechanism' of depression," says Pariante. On the plus side, that gives us many more treatment options. "It's messy, but all of medicine is messy," he says. ∎

Clare Wilson is a reporter at *New Scientist*

Homeward bound

Where European eels start and end their lives was long a mystery. We have finally charted the details of their incredible journey, finds **Graham Lawton**

MATHIEU FOULQUIE/BIOSPHOTO/MINDEN PICTURES

RIGHT now, millions of sinuous, silvery fish are swimming determinedly across the Atlantic Ocean. They are snake-like, more than a metre long and have huge, bulbous eyes. They left their homes in Europe in late autumn and have been navigating westwards ever since, often swimming against the currents that once carried them the other way. They travel alone at a languid pace, never stopping to rest. By night they are near the surface; by day in the depths. Their journey will take more than a year. Many won't make it. But those that do have a reward awaiting them: sex and death in the Sargasso Sea.

This is the ultimate goal, and fate, of the European eel (*Anguilla anguilla*), a remarkable and enigmatic species that has nourished the human imagination, and belly, for millennia. Their life cycle is fascinating and their final journey, the details of which have only recently been discovered, is jaw-dropping. "This is a species which is notoriously difficult to understand," says eel expert Jack Wootton of the Forth Rivers Trust in Edinburgh, UK. What we do know for certain is that the European eel is critically endangered and needs help to recover, or woe betide it and the ecosystems it nourishes.

This species starts life far from Europe in the Sargasso Sea, a region in the western Atlantic that is defined by the four ocean currents that form its boundaries. From December to May adult eels spawn there, and their larvae – known as leptocephali – start a long journey to Europe and North Africa. They are largely carried by the prevailing currents, which drag on their leaf-shaped bodies, but they also navigate. "There's some active swimming," says Ros Wright of the UK's Environment Agency in Feering, Essex.

From the Sargasso Sea, the leptocephali fan out and eventually arrive across the western shores of Eurasia and Africa, from Iceland to Morocco, while also penetrating deep into the Mediterranean and Black Sea. By now they have reached the next stage of their life cycle, becoming glass eels, which are less than 10 centimetres long, thin and transparent, but distinctly eely (see diagram, page 44).

For the next few months, glass eels wash in and out of estuaries, feeding and growing and gradually transforming into elvers, which are dark brown and about 12 cm long. At this point they are ready to swap the sea for freshwater and make their way up rivers and streams to find a place to grow up. Once settled in a lake or river, they transform again, into yellow eels. "This life stage can be decades long," says Wootton. "And this is usually what we see when we see eels within our rivers and lakes and lochs."

Eventually, though, it is time to return. Following an unknown cue, our yellow eel begins its final metamorphosis into a silver eel. "It doesn't fully mature yet, but it's starting the process," says Wootton. "It has an incredible metallic silver belly, a really dark back, its eyes grow and enlarge, pectoral fins grow, its digestive tract changes and its sexual organs start to develop." "They're so silver it's ridiculous, a really blue silver," says Andy Don, also of the UK's Environment Agency. "Incredibly beautiful animals." The silver eels then head for the Sargasso Sea, where they mate for the first and last time, spawn and die.

Until recently the details of that incredible journey were obscure. Silver eels were known to set out between September and December, but their route to the presumed spawning grounds and how long it took to get there were lost at sea. That wasn't for lack of trying.

Origin myths

Scientific interest in the eel life cycle goes back to the late 19th century. Elvers and adult eels were a key food in Europe and interest was growing in aquaculture, but nobody had ever seen a larval eel or witnessed sexual activity between adults.

In 1896, Italian biologist Giovanni Battista Grassi, who was working at an oceanographic station in Messina, Sicily, claimed he had solved the enigma. While sampling in the Strait of Messina, he caught a specimen of *Leptocephalus brevirostris*, a small, transparent, leaf-shaped fish that was believed to be a species in its own right. He dissected it and found it had between 112 and 117 vertebrae, which suggested it wasn't a separate species at all, but a young European eel. He later observed all the life stages of the eel in the sea around Messina and finally reared specimens of *L. brevirostris* in an aquarium. When they metamorphosed into elvers he had clinched it. He surmised that European eels spawn in the deep Mediterranean and their larvae are only seen when occasionally brought to the surface by whirlpools, such as are found in the Strait of Messina. The Royal Society published his findings and awarded him the prestigious Darwin Medal for his work.

Grassi was right about his specimen being the larval form of a European eel, but wrong about its origins. Enter Johannes Schmidt, a marine biologist at the Carlsberg Research Laboratory in Copenhagen, Denmark. ›

In 1904, he was aboard Thor, a research vessel, between Iceland and the Faroe Islands. He and his colleagues took water samples near the surface and unexpectedly found an eel larva. Schmidt had found his “white whale” and on subsequent voyages in the Atlantic he pursued it with vigour, always finding smaller and smaller larvae the further west he went. By 1912, Schmidt was convinced that eels spawned not in the Mediterranean, but somewhere in the western Atlantic. He extrapolated his data and marked the spot: the Sargasso Sea.

He submitted his findings to the Royal Society in 1912, but it knocked him back on the grounds that it thought Grassi had the eel-origin issue sewn up. However, the journal *Nature* didn’t have any skin in the game and published Schmidt’s research. In 1930, the Royal Society finally recanted and awarded Schmidt the Darwin Medal.

As a result of Schmidt’s 1912 paper, the Sargasso Sea became accepted as the hitherto-mysterious location of eel reproduction, meaning that European eels must somehow migrate up to 10,000 kilometres on the return journey to complete their life cycle. But there was still a problem: nobody had ever seen an adult eel in the Sargasso Sea or any eel eggs.

In the 1970s, fish scientists used ultrasound transmitters to track the first few hours of migration by five eels from the northern Bay of Biscay, off Spain, which confirmed that they at least strike out in the right general direction to reach the Sargasso Sea. But it wasn’t until the advent of pop-up satellite transmitting tags, which can be attached to an eel and collect data on movement, that it became possible to track them for extended periods. After a year, or when the eel dies, the tags float up to the surface and submit their data.

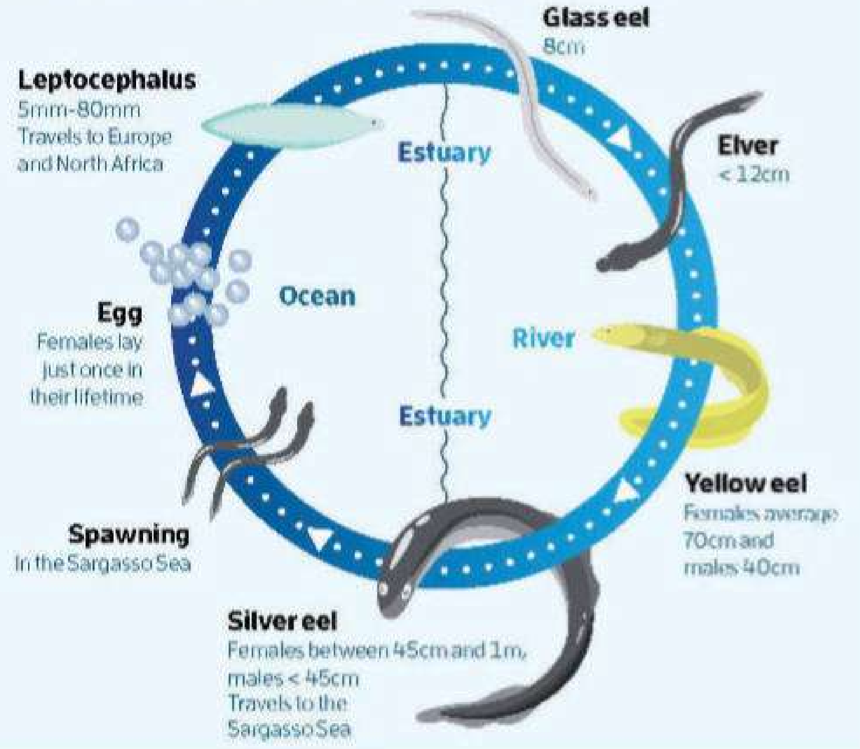
JACK PERKS/ALAMY

Every year some 350 million glass eels are trafficked to Asia

In 2008, a project called Eeliad used pop-up tags to track 80 silver eels from all over western Europe over six months – that being the limit of tag battery life at the time. All the eels headed towards the Azores archipelago, around 1400 km off Portugal; one actually made it there before its tag failed. “That’s the furthest that eels had been tracked from Europe going towards the putative spawning grounds,” says Don. “It really was quite ground-breaking.”

Life cycle of the European eel

It takes eel larvae between one and two years to travel around 6500 kilometres from the Sargasso Sea in the western Atlantic Ocean to the rivers of Europe and North Africa. The adults must make the return journey to spawn


Glass eel
8cm
Leptocephalus
5mm-80mm
Travels to Europe and North Africa
Estuary
Elver
< 12cm
Egg
Females lay just once in their lifetime
Ocean
River
Estuary
Yellow eel
Females average 70cm and males 40cm
Spawning
In the Sargasso Sea
Silver eel
Females between 45cm and 1m, males < 45cm
Travels to the Sargasso Sea

SOURCE: THAMES RIVER TRUST

That led to a hypothesis that the Azores served as a way station on the migration, and hence would be a good place to try to finally track eels all the way to the Sargasso Sea. Wright wanted to test that idea, but there was no funding available, so, in 2017, she went on holiday there and asked around. On a birdwatching trip, a local guide told her that there were freshwater eels in the Azores, but that not much was known about them, not even what species they were.

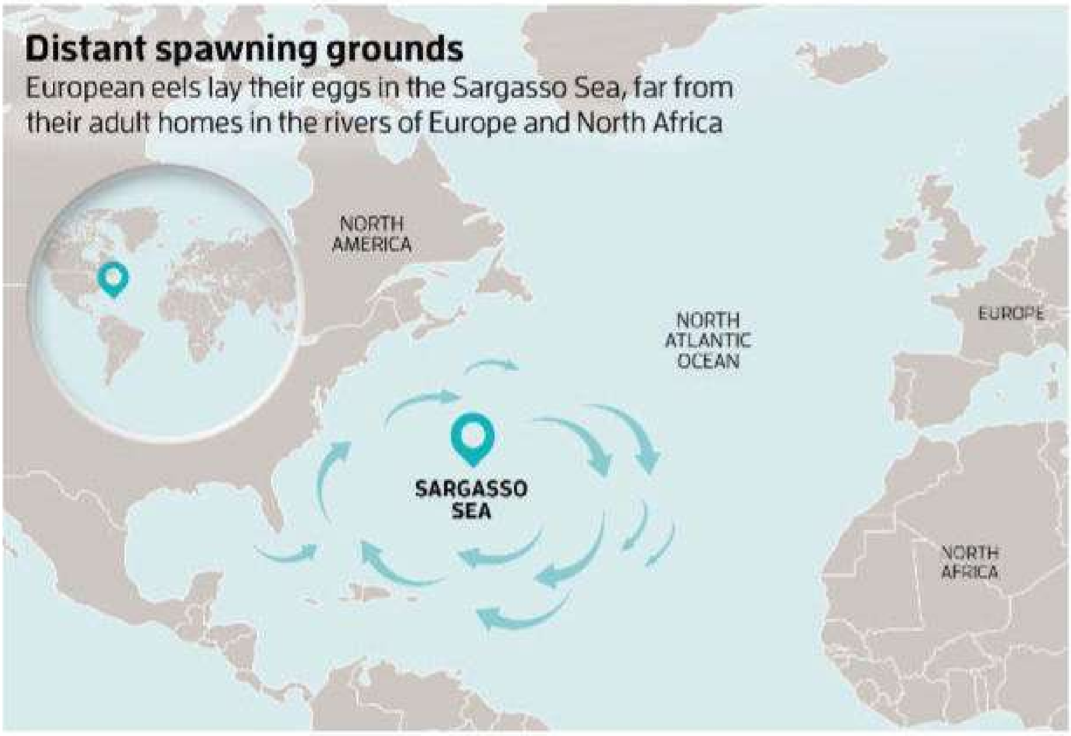
Later that year, Wright, Don and others went on an expedition, setting off with just a few essentials in their hand luggage. “Where some people might pack their Speedos and some beach clobber, because we were doing it on a shoestring, our suitcases were just full of fisheries management paraphernalia,” says Don. During a long and arduous trip, they found silver eels in Azorean waterways and confirmed that they were European not American. The project became official and got a name: Eel Trek. In 2020, they caught 23 silver eels in the Azores, tagged them, released them into the Atlantic and waited on tenterhooks for data to come in.

Slow progress

Over the following months, many of the tags failed or became detached from their owners, leaving just a handful in action. The day of reckoning – when the remaining tags would give their data – was 27 November 2020. It was a breakthrough moment, says Wright. Five of the eels had reached the edge of the Sargasso Sea and one was actually in the presumed spawning ground. “This is the first time we’ve been able to track eels to the Sargasso Sea and we are delighted,” says Wright.

One big surprise was that the leg of the journey from the Azores to the Sargasso Sea takes the best part of a year. The presumption was that silver eels go hell for leather to reach the Sargasso Sea for the first spawning season after their departure. But the truth is that they dawdle and meander for months, travelling an average of just 6.5 kilometres a day, skipping the first season and joining the next one.

Eel Trek isn’t just about closing the loop


Distant spawning grounds

European eels lay their eggs in the Sargasso Sea, far from their adult homes in the rivers of Europe and North Africa

on a long-standing mystery, but also about the urgent task of saving the European eel from extinction. This species has been in decline for centuries as wetlands were drained. "Italy has just 5 per cent of what it had in Roman times," says Andrew Kerr of the Sustainable Eel Group, a pan-European conservation organisation based in Brussels, Belgium. But since 1980, the population has slithered spectacularly downwards and the European eel is now classed as critically endangered. The number of glass eels arriving in Europe – termed recruitment – has fallen by 90 per cent or more, and has almost dried up completely in some places.

"This is an incredible, monumental crash in the species," says Wootton. "And we're not 100 per cent sure why this happened. What we do know is that river barriers, that pollution, that illegal fishing, that 101 other causes are still impacting them today."

Wright suspects climate change is also a culprit, perhaps by weakening the ocean currents the eel larvae use to surf to Europe, or by changing the nature of the Sargasso Sea. This is why her team's results may help with conservation. The worry, she says, is that so few silver eels will make it back to breed that the population is no longer viable.

There are actions that we can take. One is to remove or modify river barriers such as weirs and dams. These are a major problem for eels, preventing them from swimming up rivers as elvers and escaping again once they are ready to breed. There are some 1.2 million barriers in Europe, many of them no longer serving a useful purpose. Wootton leads a project removing these or installing structures such as eel passes – a set of water-filled steps that eels can leapfrog up or down.

Illegal fishing is another major issue. The black market for European eels sold in Asia is vast, worth an estimated $3 billion a year, according to Europol. In 2018, an estimated 100 tonnes of glass eels were illegally trafficked to Asia. That translates into 350 million glass eels, says Kerr, or about a quarter of the 1.3 billion that the International Council for the Exploration of the Sea estimates make it to Europe after each breeding season. "This is the biggest wildlife crime on the planet for a living creature," says Kerr.

The eels are usually packed in suitcases and smuggled from European airports to Japan, South Korea, China and Malaysia. The profits are vast – an eel that sells for 10 cents in Europe can eventually fetch 100 times that value in Japan. Authorities are increasingly taking the problem seriously. A decade ago, smugglers were routinely given a slap on the wrist and a small-fry fine. Earlier this year, a smuggler in Spain was hit with a €7.2 million fine and a 15-month prison sentence. Trafficking is now a fifth of what it was, but that may be more down to covid-19 travel restrictions than policing. "It's been an incredible battle to expose this criminality and it's not over, we've got many more fights," says Kerr.

Scientists releasing eels caught on France's Mediterranean coast

JEAN E. ROCHE/NATUREPL

There are tentative signs that eel populations have already stabilised. From 1980 to 2010, glass eel recruitment declined 15 per cent a year. In 2011 the decline stopped, and recruitment has been bumping along the bottom ever since, but it is still in a terrible state, says Kerr. "This is a critically endangered fish".

The consequences of this decline ripple through the whole ecosystem. Eels once represented a huge influx of nutrients into wetland environments, providing food for species such as otters and bitterns. "All this work that we do on eels has got wider biodiversity benefits and that's just so important now," says Wright.

In the meantime, the remaining silver eels continue to make their epic return journey. In 2021, Eel Trek tagged another 16 from the Azores and they are currently en route to their spawning grounds. Wright says they have extended the life of the pop-up tags to 18 months, so they can discover what the eels actually do once they arrive in the Sargasso Sea.

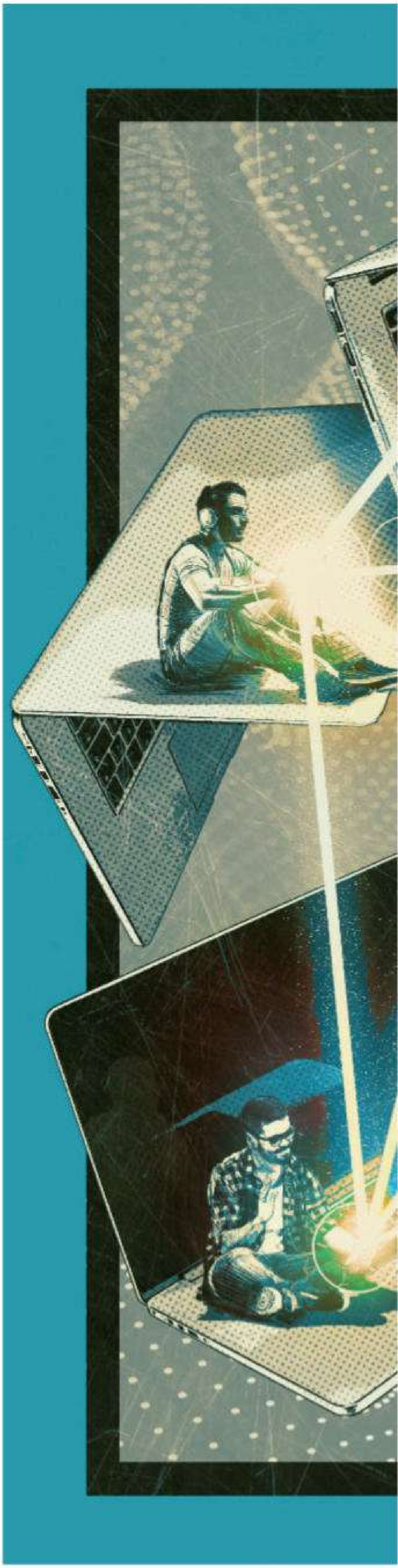
Even then, the eel will remain an enigma. Nobody has ever found eel eggs in the Sargasso Sea, though they must be there. That would truly close the loop. Their amazing, metamorphic life cycle is also not well understood. "We still don't know what controls a lot of their life cycle systems," says Wootton.

Then there is the small matter of how they navigate back to their birthplace, across up to 10,000 km of open ocean. "The navigation, I think, is still something we really don't know," says Wright. It could be guided by magnetic fields, or maybe visual cues from the sky – hence the huge eyes and shallow swimming by night. It could be genetic: American eels also spawn in the Sargasso Sea, but head east as their European counterparts head west; hybrids occasionally arise and head north. Those route-finding skills could be down to something else entirely. But that is a mystery that the European eel may well take to its watery grave. ▮

Graham Lawton is a feature writer for *New Scientist*

Weaving a new web

The online world is controlled by a handful of powerful companies. Is it time we put a stop to that by building a new version of the internet? **Chris Stokel-Walker** logs on to web3


CHRIS MALBON

ON A gloomy Thursday morning in Newcastle, UK, I sit with my laptop open playing a game. But I am not, I will admit, having much fun. Besides the occasional pixelated images of a space hero, it is mostly a text-based, multiple-choice offering, with prompts encouraging me to imagine that I am on the planet Veles and asking where I would like to mine next. The experience isn't enhanced by the fact that I have had to spend 20 minutes linking a cryptocurrency wallet to the game in order to get this far.

Why am I putting myself through this? Because, believe it or not, this game is supposed to be the future of the internet, or at least part of it. It is one of the world's top-rated distributed apps, a manifestation of what some see as a shiny new phase of the online realm called web3.

While my adventures on Veles are amusingly awful, there is a serious side to my foray into the wilds of web3. There is a chorus of voices calling for a new iteration of the internet. And it isn't hard to see why: the tech giants that currently control our online world are wracked by scandals, are haemorrhaging money and don't seem equipped to solve the problems of online misinformation and hate. So what is web3, how does it work and can it really offer a better digital future?

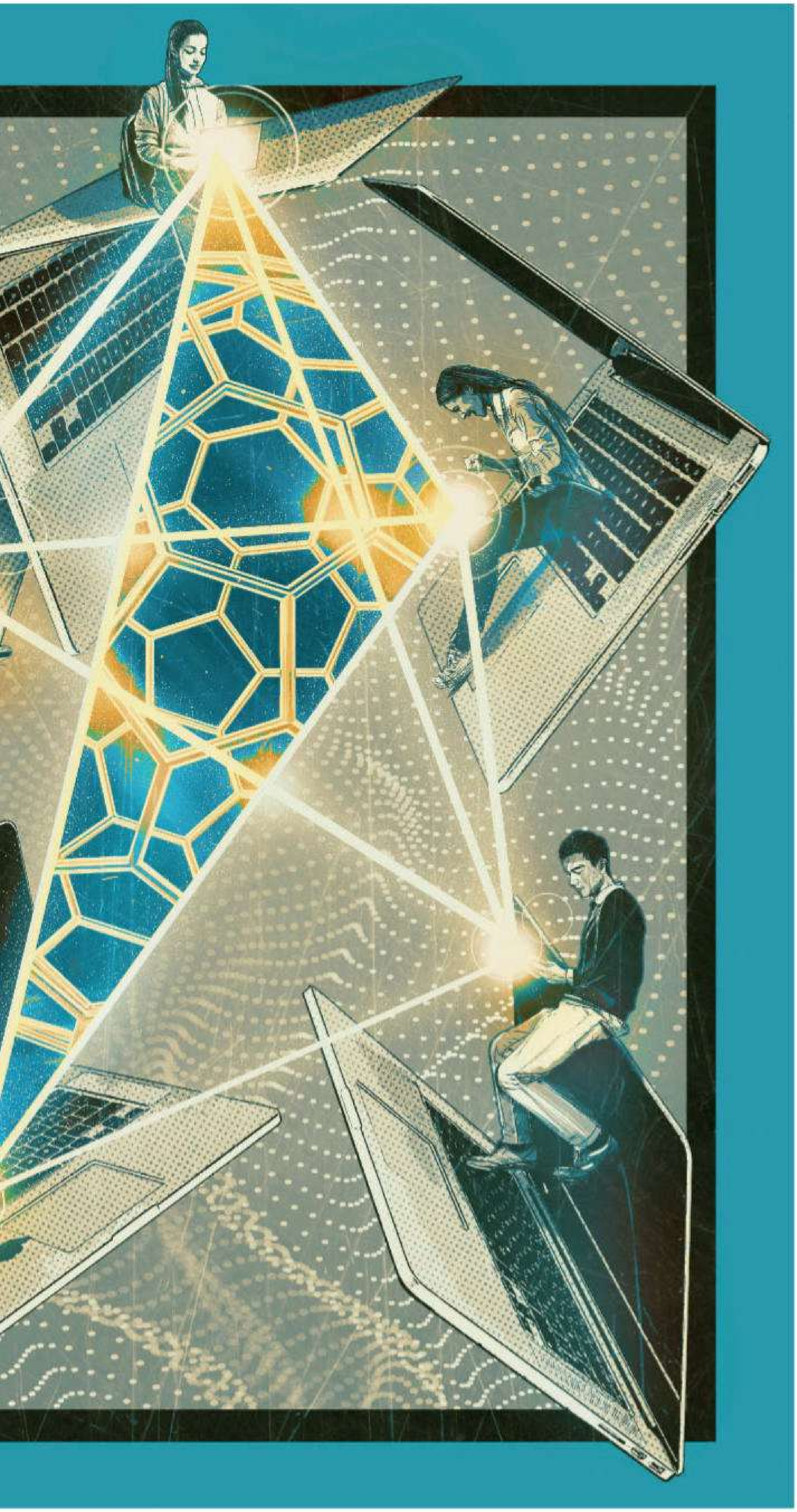
The idea of a connected set of computers – the internet – goes back many decades. But the world wide web, the shared set of websites that we can view online via those connected computers, was created in 1989 by Tim Berners-Lee. Even in the early days, he had big plans for the web's future (see "The semantic web", page 48). In the first generation, known as web 1.0, users hosted their own websites and email on home or institutional servers. It was an idyll for hobbyists, full of promise and revolutionary zeal.

It couldn't last. Users had to manage their own affairs, keeping computers running constantly to host their own web pages and inboxes. It was too taxing for all but the most dedicated enthusiasts. So, during the late 1990s, companies stepped in. There was GeoCities, for instance, which hosted your web pages so you didn't have to. Hotmail and Yahoo did something similar for email.

The phrase web 2.0 was coined in 1999 as we began to move to those convenient, centralised providers. It really became popular in 2004 with the arrival of the Web 2.0 Conference, held annually in California for almost the next decade. This era saw the launch of several companies that would exert an increasing grip on our lives: YouTube, Facebook, Twitter, Instagram and more.

On the one hand, the rise of these titans brought huge benefits. Web 2.0 broke down barriers to the online world. We could log onto most websites with a Google account and pay for items online with PayPal. It was all so easy.

But on the other hand, a succession of more recent scandals showed us that web 2.0 has



"A succession of recent scandals has shown us that web 2.0 has serious downsides. In short, the rose-tinted spectacles have come off"

serious downsides. One of the highest-profile examples came in 2018, when it emerged that the company Cambridge Analytica had harvested the personal data of millions of Facebook users, built profiles of them and then sent them politically polarising adverts on their feeds. The company did work for Donald Trump's campaign for US president in 2016.

In 2021, whistle-blower Frances Haugen, an ex-employee of Facebook (since rebranded as Meta), released a tranche of documents that she claimed showed that the firm prioritised its growth above safeguards to protect young people from potentially damaging content.

Most recently, in autumn 2022, Elon Musk completed his takeover of the social network Twitter. Within days, he had gutted its staff and aired the idea of charging users for verification. He has also said he is a "free speech absolutist" in the past. For many users who had invested time in building their profile on Twitter, it felt like time to leave.

In short, the rose-tinted spectacles have come off. The view is that tech giants are too powerful and untrustworthy. "We're seeing the impact of big tech on our lives," says Samer Hassan at Complutense University of Madrid, Spain. "And people have growing concerns about how tech is taking over."

This malaise is part of what is fuelling the talk of web3. You can't get far in the tech sphere without coming across it. You may have heard the hype about non-fungible tokens (NFTs), › "At present, web3 rebuilds some of the hurdles that previous generations of the web broke down"

cryptographic assets often associated with ownership of digital art that are commonly spoken of in the same breath as web3. There is a deluge of news articles asking if web3 is the next big thing, venture capitalists extol its virtues and the management consultancy firm McKinsey put out a report on web3 in September 2022 saying that web3 could have "potentially transformative effects".

From apps to dapps

If you find yourself hazy on how to define web3, you aren't alone. It tends to be spoken of in vague terms and comes mixed with unfamiliar concepts like those NFTs. The crucial thing to get your head around is the blockchain. This is a digital ledger, a set of computerised records divided into blocks, each of which is stamped using cryptographic keys to provide a cast-iron assurance of its authenticity. Think of it like a super-secure digital equivalent of keeping the receipts from your shopping. Even more important is the decentralised blockchain. The first was created by a person or persons calling themselves Satoshi Nakamoto in 2008. The twist was that the ledger is stored in a distributed fashion across a large number of computers. Not only was it as trustworthy as a regular blockchain, it couldn't be controlled by any one person.

Nakamoto's creation would go on to form the basis of the first cryptocurrency, bitcoin, in which each block was like a unit of money. In 2015, along came Ethereum, another blockchain platform that has been used in all sorts of ways, including as the basis of another cryptocurrency, Ether, and as a way to implement smart contracts, where the terms of an online deal or purchase are written into a blockchain and self-execute when certain conditions are met. Most crucially, Ethereum provided, for the first time, a way to build apps that weren't hosted by an individual company, but on a decentralised blockchain.

Web3 draws heavily on these distributed apps (dapps) to avoid the problems of centralised control. For Gavin Wood, a co-founder of Ethereum who coined the term web3 in 2014, there are several potential advantages. First, because dapps are decentralised, they are in a sense hosted by everyone rather than one company – Wood has spoken of this as being more "democratic".

The semantic web

An associated but distinct concept to web3 (see main story) is the semantic web. First proposed in 2001 by the web's founder, Tim Berners-Lee, alongside computer scientists James Hendler and Ora Lassila, the idea is that we should develop the web so that all its content is machine-readable – in other words, it can be "understood" by any computer. The goal was to make life more convenient for us all as the world moved online. "The Semantic Web will bring structure to the meaningful content of Web pages, creating an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users," Berners-Lee and his co-authors wrote.

What this means is that the semantic web requires websites to provide metadata that can then be analysed by software, apps and services. Every element on a web page would be labelled to aid computer comprehension. For instance, the phrase "Chris Stokel-Walker lives in Newcastle" would be labelled with invisible markers that told computers "Chris Stokel-Walker" was a name and "Newcastle" was a location.

The benefits of labelling all the web's content like this could be huge. In a world where AI is increasingly intelligent and pervasive, improving its ability to decipher our online repository of knowledge could help make it even smarter and, crucially, more effective at interacting with the human world. In his original vision of the semantic web, Berners-Lee imagined a situation where a web browser could pull treatment requirements for a patient from a doctor's website, then find pharmacies that stock the relevant medicine and services that can provide, for instance, physiotherapy. Any appointments could be seamlessly booked by cross-checking availability at a physiotherapist's office with the patient's calendar.

However, labelling the internet's data in this way is a labour-intensive task: only a minuscule fraction of the world's web pages contain semantic information. Adding it requires trawling through the contents of a website and its underlying computer code, then classifying the information based on its relevance. Those dedicated to this task do it because they see the promise of the semantic web. Every year, researchers hold the International Semantic Web Conference; the most recent iteration, hosted virtually by China, concluded in late October. But while the academic meetings continue, the semantic web isn't – as yet – something most users would recognise.

MARK RICHARDS/ZUMA WIRE/ZUMAPRESS.COM/ALAMY LIVE NEWS

BEN ROSSER/BFA.COM

THE SAN FRANCISCO CHRONICLE VIA GETTY IMAGES

Three eras of the web (clockwise from top): ads for early internet service provider Yahoo! in 1998; the Web 2.0 Summit in 2009; Bored Ape art, which is often associated with web3, displayed at a festival in 2022

Second, we no longer have to trust that companies will provide services online – the guarantee can be built into the underlying blockchain. Third, verifying who people are could be more robust on a decentralised web. People could still remain anonymous, but their activity over time could be reliably tracked, thanks, again, to the blockchain record.

In an idealised future, web3 could challenge the tech giants' monopolies and make it far easier to root out automated fake accounts, or bots, spewing hate speech. It could also, in principle, allow users to move their profiles and data between online services more simply, because their data would be stored on a shared blockchain rather than squirreled away on a company's private servers.

In 2017, Wood and others founded the Web3 Foundation to help fund and develop ideas that could enable this new online environment. "The fundamental point is decentralisation," says Alistair Stewart, lead researcher at the foundation. "We don't want to trust individual corporations, or even individual individuals. It's more likely we would like to trust a wide group of people."

All this is what prompted me to try out web3 myself. So on that gloomy Thursday, I opened up an ordinary internet browser and searched for lists of popular dapps. Eschewing the hordes of finance apps, I went for the most popular dapp game, called *Alien Worlds*. It sounded fun, exotic. I clicked through and a tempting opening screen appeared.

It was quickly replaced by a pop-up asking me to sign up for a special kind of cryptowallet and to link this to a cryptocurrency account. Being a tech journalist, I already had the latter, but this was still a lengthy, tricky process. When I finally got into the game, it was a disappointment. The basic idea seemed to be to mine resources, but honestly it hardly hung together and was pretty boring. Every time I wanted to do anything, a pop-up appeared asking me to approve a transaction on the blockchain. The whole experience was glitchy and frustrating.

My travails with something as simple as a space exploration game highlight the first challenge of web3. Unless you are tech savvy, the process isn't exactly frictionless. At present, web3 rebuilds some of the barriers that the prior generation of the web broke down. "There's a huge hurdle in user experience for any decentralised solution," says Stewart. "I don't think people have quite got it yet."

This technical complexity has created a second problem that might feel like history repeating. Because web3 relies on users implementing complex digital technology, companies are springing up to do it for them. Just as Google and other giants sprang up because web 1.0 was a bit of a pain, new companies, such as Ethereum and Coinbase, are becoming the gatekeepers to web3. "It's all centralised in terms of the people that have the technical expertise and money to develop and put out this stuff in the first place," says Catherine Flick at De Montfort University in Leicester, UK, who studies computing and social responsibility.

The paradox of web3

Given all this, you might be wondering how many people are using web3. Not many. According to a survey by market research company Opinium, 67 per cent of people say they have never heard of web3. Stewart admits that, at present, the web3 holdouts are "almost everybody, and almost everything they do".

The success of web3 also hinges on an equation: how annoyed are people with web 2.0 and how does that weigh against the difficulty of using web3? "Most people just want to be able to do their work without having to faff about, and it's not going to solve that problem for them," says Flick. While users may lament that Google or Meta gets to learn more about them every time they log onto a third-party website using their Gmail or Facebook accounts, they appreciate the convenience.

And that is the inherent paradox of web3. Keep it strictly decentralised and it will be too complex for most people to use; relax this requirement and you put off its staunchest backers. While some might think that a few gatekeepers wouldn't do any harm, not least because they would be less powerful than the big tech titans they are trying to replace, those who currently dictate the future of web3 see that as a step too far. Instead, their approach is: build it and they will come.

I never did manage to mine my rocky coastline on Veles, by the way. In the end, *Alien Worlds* began to throw up the same error message time and time again. It wasn't that I was digging myself into a hole. More that I could barely get my metaphorical shovel into the ground. ▮

Chris Stokel-Walker is a journalist based in Newcastle, UK

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Citizen science

Dive into the deep

You can help in the hunt for neutrinos while exploring deep-sea ecosystems with this online project, says **Layal Liverpool**

Layal Liverpool is a science journalist based in Berlin. She believes everyone can be a scientist, including you. @layallivs

What you need

Access to Deep Sea Explorers via zooniverse.org

Citizen science appears every four weeks. Share your citizen science adventures with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistCitizenScience

Next week

The science of cooking

I AM heading under the sea to help physicists find traces of one of the universe's most mysterious particles. You can join me by participating in the Deep Sea Explorers project, which is looking for volunteers to remove noise from data collected by the KiloMeter Cube Neutrino Telescope (KM3NeT) at the bottom of the Mediterranean Sea.

Neutrinos are tiny, invisible elementary particles that are extremely elusive and difficult to observe under normal conditions. But when neutrinos interact with matter, the resulting charged particles that are produced emit shock waves of bluish light known as Cherenkov radiation, which KM3NeT can detect. Because it is located deep under the sea, the telescope is shielded from other light emissions, such as from the sun or moon above, as well as from cosmic radiation.

Since the sea is also teeming with life, researchers analysing data from the telescope must filter out background sounds and light in the water in order to home in on real neutrino observations. In particular, sounds produced by marine mammals can interfere with the telescope's acoustic triangulation system, while bioluminescence in the deep sea can mix with the Cherenkov radiation that the telescope is designed to detect.

You can help distinguish the signal from the noise by browsing observations from the telescope online and classifying background sounds, such as whale clicks, as well interfering light from bioluminescent life. There is a tutorial explaining how to classify them on the project's website.

KM3NET

Thousands of people have participated in the Deep Sea Explorers effort since it launched in 2019. In addition to helping physicists pinpoint true neutrino observations, the classifications made by volunteers online are contributing to deep-sea marine biology research.

"This is not just about the universe, it's about the beautiful world we have at the bottom of our sea," says Gwenhaël Wilberts De Wasseige at the Catholic University of Louvain in Belgium, one of the team.

As a neutrino astronomer, she hopes to use the information gleaned from the project to help in her search for low-energy neutrinos coming from the sun, as well as from astronomical events such as supernovae. The classifications from volunteers are already helping to train artificial intelligence to quickly filter out true neutrino signals from background noise.

That very same background noise provides data for marine biologists, who are using the information on sound and light produced by organisms under the sea to learn more about deep-sea ecosystems and whale behaviour. "I like to say that the noise of someone is the signal of someone else," says Wilberts De Wasseige. ▮

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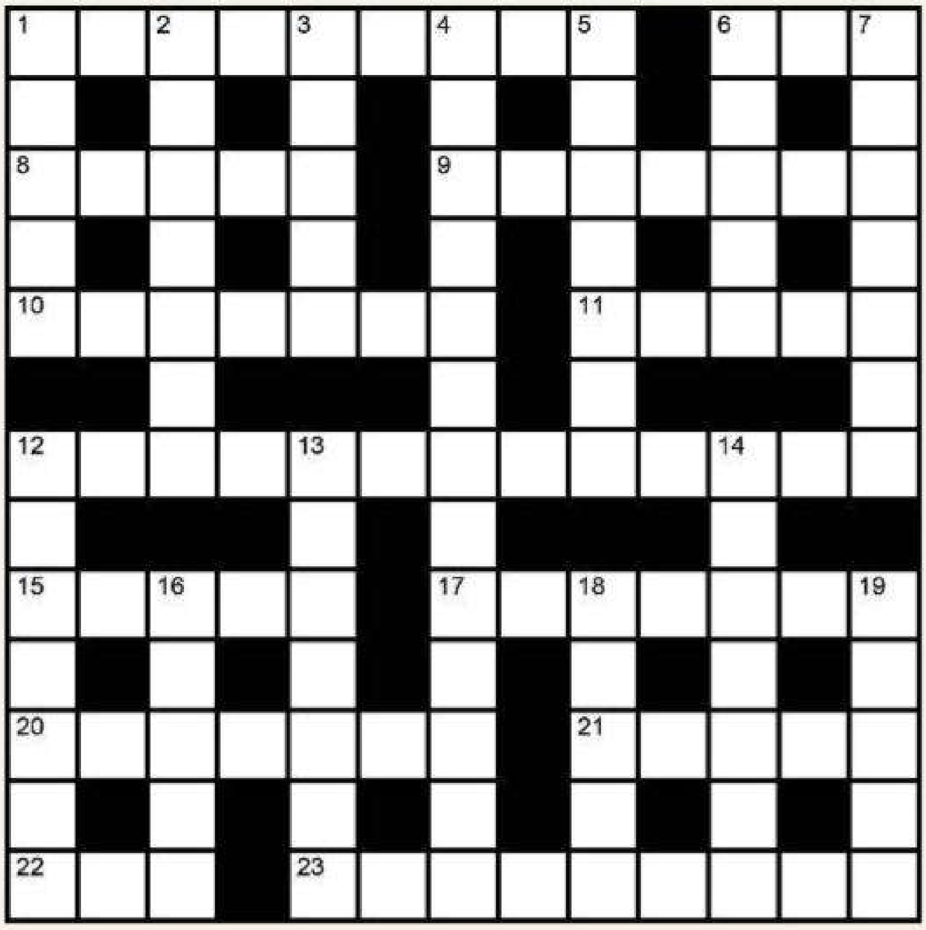
Cryptic crossword #101 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Factory specialist is after protruding feature in floor protector (9)
6 Dump stone the wrong way (3)
8 Artefact seen amid rare lichen (5)
9 Contents of acid chart appropriate for referencing (7)
10 Anticoagulant cured her pain (7)
11 Jog back with both ends of spine becoming tender? (5)
12 Crew members vocally deride sullen people keeping retrograde schedule (4,9)
15 Mike to be in French unit (5)
17 Pitch a tent close to bush or aromatic type of tree (7)
20 Truncate first half of show with new tenor (7)
21 Extremely cold germanium jar topper (5)
22 Banned substance two days before start of tournament (3)
23 Liberal portrayed like a shark (9)

DOWN

1 Planet with hot swampland (5)
2 Caribbean music improved cosplay (7)
3 Take on popular scoundrel (5)
4 Radiation engineer selectively replicated bits of candies (13)
5 Sadly, it ain't a moon of Uranus (7)
6 Root counter getting upset (5)
7 Spin like a tilted top and break under pressure (7)
12 Puzzled large birds trapped in garden plot (7)
13 Very simple round avian dwelling put on record (3-4)
14 Before word of greeting, bot doesn't begin strategy game (7)
16 Aggressively promote eating river fish (5)
18 Between postgraduate degrees, head of geology melted rocks (5)
19 Florid pal taking rook instead of bishop (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #185
set by Bethan Ackerley

1 Who invented the voltaic pile in 1799?

2 The bacterium *Borrelia burgdorferi* causes which disease?

3 A plant that grows on another plant but isn't parasitic is known as what?

4 The tears of wine phenomenon, where beads of clear liquid appear inside a glass of wine and drip down, is caused by which effect?

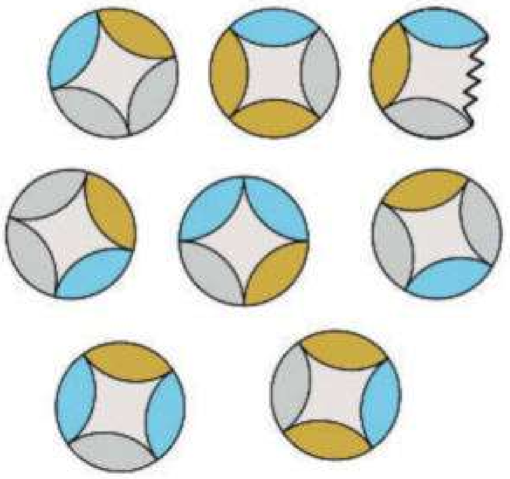
5 Which of Jupiter's Galilean moons isn't an icy world?

Answers on page 55

Puzzle
set by Peter Rowlett
#205 Buried shields

The burial chamber of Queen Count-M-Up of the Mat e'Matic people has been discovered! Archaeologists know that her people greatly appreciated diversity in life, and they believe she was buried with a set of painted shields that illustrate this by displaying all possible combinations of three colours (gold, silver and blue) in four sections.

Opening the tomb, they quickly find seven complete shields and one broken one. What colour is the missing section? And when they discover the ninth shield, what will it look like?



Solution next week

SILKE WOWERIES/GETTY IMAGES

An eardrum seems to handle many audible frequencies at the same time. How does it do this?

This week's new questions

Eardrum symphony **How can a vibrating eardrum convey the rich symphony that we hear? Why don't the various frequencies interfere with each other?** ***Derek Johnson****, Moreton-in-Marsh, Gloucestershire, UK*

Yawning gap **Is it possible to yawn without closing your eyes? If not, why?** ***Helen Kendall****, Leicester, UK*

Double trouble

If identical twin brothers are each potentially the father of the same child, is there a way to determine, genetically, which is the father?

Antoon Pelsser
Maastricht, The Netherlands
In a recent Dutch court case, a person suspected of rape claimed that his identical twin brother was the perpetrator. A careful DNA analysis revealed a few differences in the DNA between the brothers. And the DNA profile of the suspected twin matched with that found on the victim.

Gabriel Nève
Aix-Marseille University, France
From one generation to the next, there are always some small changes, called mutations, among the 3 billion or so base pairs of the human genome.

In order to identify which identical twin is the father, you would need to identify the mutations that ended up in their reproductive tissue, or germ line, and which occurred soon after the fertilised egg split into two, going on to develop into the twins.

"A careful forensic DNA analysis revealed the few differences in the DNA between the identical twin brothers"

On average there are between 10 and 20 such mutations between identical twins. To identify these, one would need to get samples of semen from both twin brothers, and tissue samples from the child and its mother and then obtain high quality genetic sequences from all of these.

Even so, it isn't always possible to identify which of the brothers is the father, as in one-tenth of such cases, no mutations occurred in the early development of the twins, but, in the most favourable instances, there might be more than 100 mutations. In the case of identical triplets, some mutations may affect two of the brothers and not the third one.

Derek Abbott
University of Adelaide, Australia
It is possible to determine the genetic difference between identical twins if you target single nucleotide polymorphisms (SNPs) in their DNA rather than the short tandem repeats (STRs) that are used for standard DNA tests. SNP analysis is much more fine-grained, as each SNP represents a difference in a single nucleotide, the building block of DNA.

A method to solve paternity cases involving identical twins as alleged fathers using SNPs is outlined in a 2014 paper "Finding the needle in the haystack: Differentiating 'identical' twins in paternity testing and forensics".

I also used SNP analysis to solve the "Somerton man" mystery – the case of a man found dead in 1948 on Somerton beach in Adelaide, whose identity had never been discovered.

In 2012 I realised that some of this man's hair was stuck in a plaster cast that had been made of his head, and, working with geneticists, tried to extract DNA from this hair. We tried a hair root first and it was a big flop. But we got 2 million SNPs from the hairshaft. Standard forensic wisdom is that the hair shaft is useless, however that viewpoint evolved from the world of standard crime DNA techniques that use STRs, not SNPs.

Those SNPs were used to find distant cousins of the Somerton man on genealogical DNA databases. We took the closest SNP match and built a family tree of that person. This tree contained 4000 people and on that we found a man called Charles Webb whose death had never been registered.

We then looked for more of Webb's closest living relatives (we found five of them) and tested their SNP overlap with DNA from the hair. They were all in the right range and so this confirmed that Charles was the Somerton man.

Sandy Lukats
via Facebook
Try the judgement of Solomon.

Taste the sun?

Are fruits and vegetables grown under glass, plastic or artificial light as nutritious as ones grown outside in direct sunlight?

Tony Woodward
Portland, Oregon, US
Fruits and vegetables grown in greenhouses can be as nutritious as those grown in fields under natural light. Indeed, under ideal conditions they are more nutritious and healthier.

Greenhouses provide a constant environment without the hazards of bad weather; insufficient sunlight can be corrected by electric light. Properly maintained greenhouses don't have the pests that can attack plants in the field and therefore don't need the toxic pesticides commonly sprayed over fields. Moreover, in a greenhouse, plants can be given the best nutrients not only for growth, but for synthesis of antioxidants and vitamins.

A 2012 study comparing vegetables grown in greenhouses and in the field reported higher levels of micronutrients and vitamin C in the greenhouse crops. As the authors point out, the concentration of desired nutrients depends on the fertiliser

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Tom Gauld
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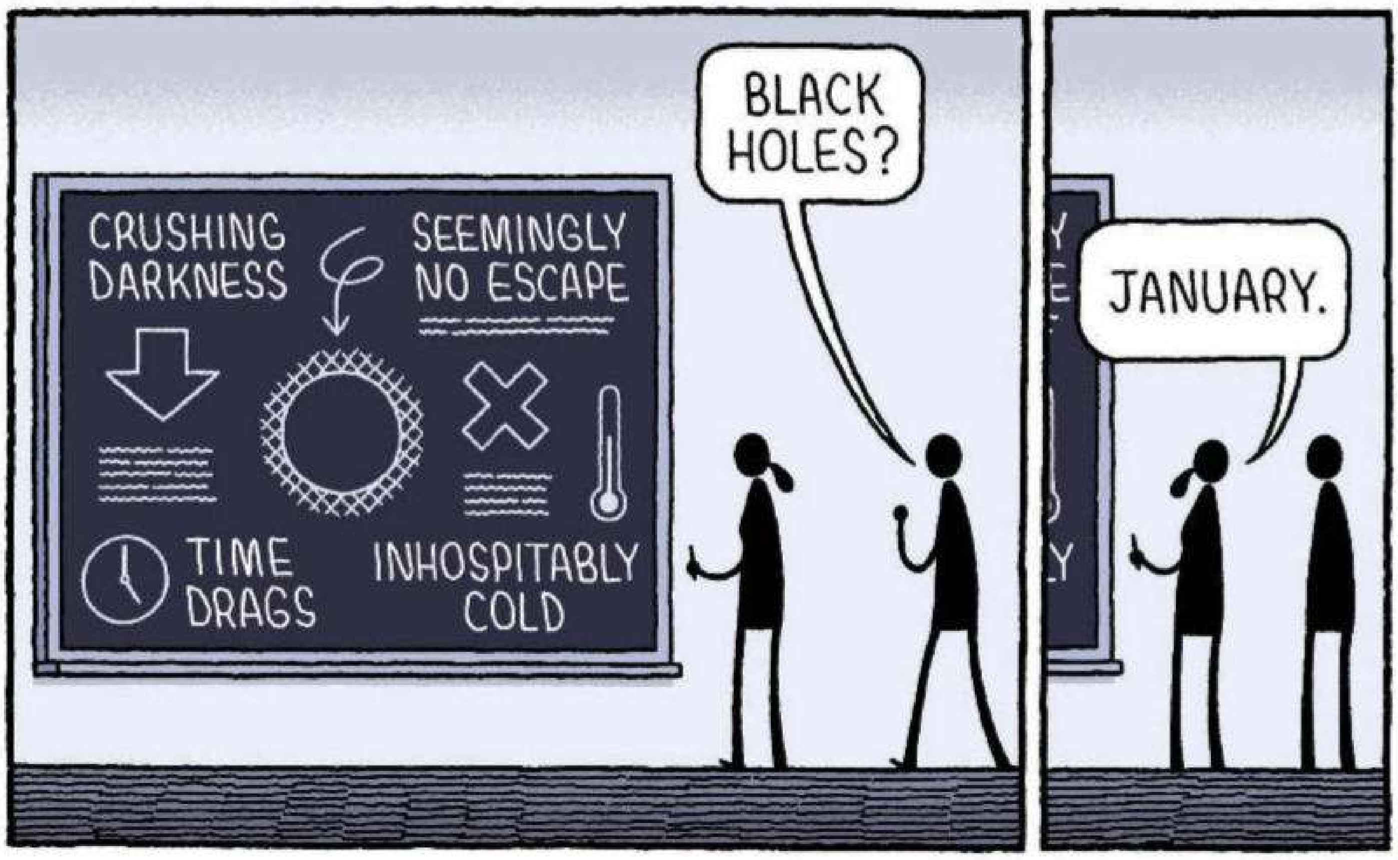


provided for plant growth.

Greenhouses allow the production of vegetables in all seasons, use 10 to 20 times less land, allow more efficient harvesting and can be erected closer to the point of sale. On the other hand, they can use a lot of electricity and water.

Kellie Walters
University of Tennessee, Knoxville, US

Over the past couple of years, my lab has been focused on controlled-environment agriculture and how we can leverage environmental controls to alter plant-produced vitamins and nutrients (phytonutrients).

While we haven't compared indoor or greenhouse-produced plants with outdoor plants directly, the main advantage of greenhouse and especially indoor plant production (think warehouse with no sunlight) is that we can precisely control the growing environment (light quantity, duration and colour, as well as the temperature, fertiliser, etc.) to elicit a desired response. That may be a combination of plant growth/yield, shelf-life, flavour or phytonutrient accumulation.

How we grow the crop influences how nutritious it is. So, one can produce a crop with low or high phytonutrients indoors, depending on the conditions. We are currently working on research to give producers/growers the tools to predictably do this.

A producer/grower can grow low or high-phytonutrient crops outdoors as well, but they can't control the growing environment like we can indoors, so this isn't as predictable.

Another factor that affects outcomes is how long a food crop has been in shipping, storage or on the shelf , as this also influences phytonutrient concentrations.

> **"Fruits and vegetables grown in greenhouses can be more nutritious than those that are grown in fields under natural light"**

Odds-on

If "the house always wins", how do professional gamblers make a living? (continued)

Christopher Smith
Whitstable, Kent, UK

It isn't always true that "the house always wins".

One instance was the famous golf "hole-in-one" coup of 1991. After extensive research, two men from Essex in the UK, John Carter and Paul Simons, worked out that some bookmakers were offering far too generous odds on a hole-in-one being achieved at professional golf events.

The bookies simply hadn't done their homework and in some cases got the odds they were offering completely wrong.

The true odds of a hole in one occurring at the events was around evens, but Carter and Simons found bookies willing to offer up to an astonishing 25/1.

By racing around the country to place many bets they won around £500,000. ▮

Answers

Quick quiz #185
Answers

1 Alessandro Volta
2 Lyme disease
3 An epiphyte
4 The Marangoni effect
5 Io

Quick crossword #124 *Answers*

ACROSS 6 Pre-op, **7** Otoscope, **10** Meccano, **11** Keyhole, **12** Catenary, **13** Ethyne, **15** Reed warbler, **20** Oil rig, **22** Alkaline, **24** Limpkin, **26** Glacier, **27** Martians, **28** Iliac

DOWN 1 Mercator, **2** Sprain, **3/18** Tomorrow's World, **4** Yolk, **5** Spooky, **6** Pumice, **8** Crystal, **9** Seven, **14** Urologist, **16** E-ticket, **17** Rhinitis, **19** Metric, **21** Lumbar, **23** Acacia, **25** Neap

#204 Think of a number
Solution

My son chose the number 5. Experimenting with a couple of numbers quickly confirms that he couldn't have repeated steps 1, 2, 3 or 5 and ended with the number 1. So he must have repeated step 4, meaning that he subtracted 60 twice. Starting with the number 1 and working back through the steps, you will find that the number he chose could only have been 5.

Snoozing grumpy face

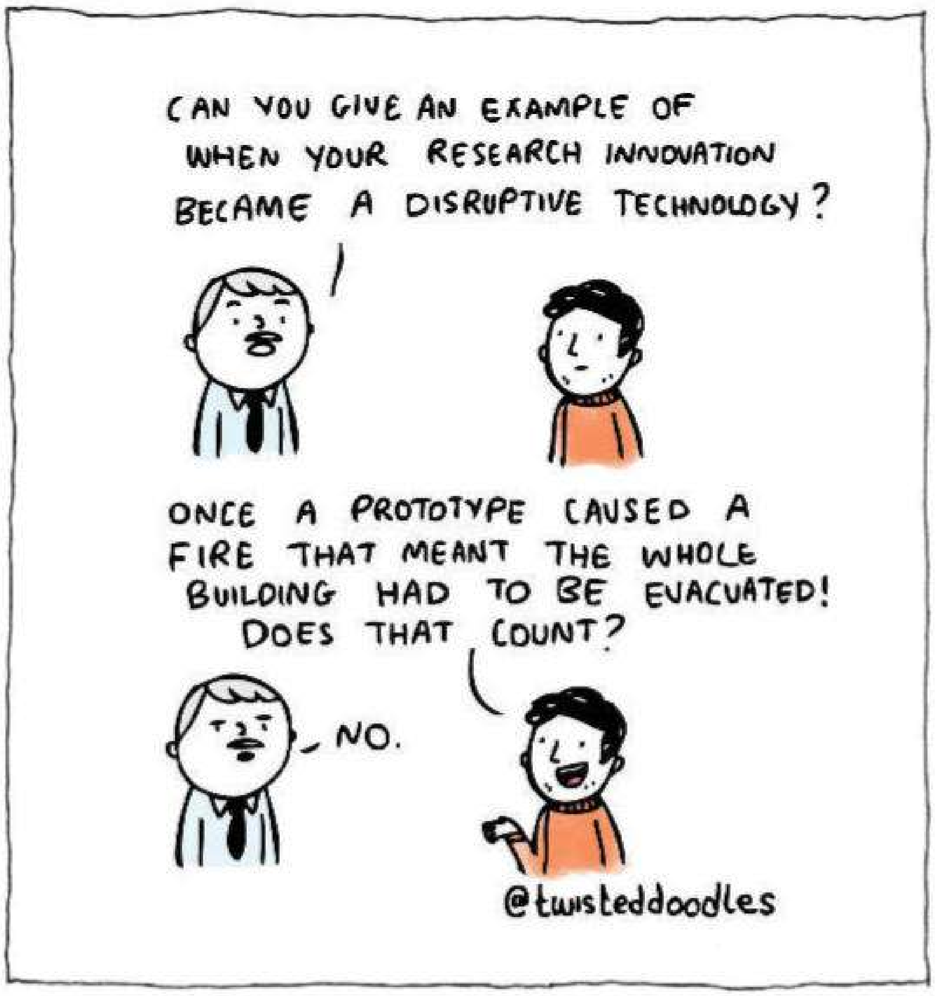
"Grumpy face during adult sleep: A clue to negative emotion during sleep?" is a study published not long ago in the *Journal of Sleep Research*. Researchers Jean-Baptiste Maranci, Alexia Aussel, Marie Vidailhet and Isabelle Arnulf at Pitié-Salpêtrière University Hospital in Paris surveiled 91 sleeping adults. They report that 89 of them frowned measurably. The measurements were made by recording the sleepers' faces and monitoring electrical activity in the muscles above their eyes.

The researchers decided that people with certain sleep disorders showed "painful expressions and rarely sadness and anger in connection with apparently negative behaviours (shouts, painful moaning, and speeches)". In ordinary snoozers, "frowns persist during normal sleep" but aren't "associated with other face movements to the point of composing negative expressions". So, for ordinary sleepers, nightly grumpy face is a normal thing.

The same team, more or less, published an earlier study called "Smiling asleep: A study of happy emotional expressions during adult sleep". It concludes that "Smiling and laughing occasionally persist during adult sleep", and hazards a cheery explanation: that "these happy emotional expressions reflect a true inner mirth".

When such things – or any things – are discussed at scientific meetings, discussants dream that all those in the audience, even the ones making grumpy faces, are paying attention. An attempt to quantify how many are actually dreaming was made in a 1983 study called "Dreaming during scientific papers: effects of added extrinsic material". It relates that: "During a series of presentations of scientific papers 40.6% of 276 subjects reported dreaming, but only 18.1% actually fell asleep. The frequency of dreaming was significantly increased by the addition of either 'very boring' or 'very interesting' slides to the usual ones, but not by 'neutral' slides."

Twisteddoodles *for New Scientist*


CAN YOU GIVE AN EXAMPLE OF WHEN YOUR RESEARCH INNOVATION BECAME A DISRUPTIVE TECHNOLOGY?
ONCE A PROTOTYPE CAUSED A FIRE THAT MEANT THE WHOLE BUILDING HAD TO BE EVACUATED! DOES THAT COUNT?
NO.
@twisteddoodles

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Consideration of items sent in the post will be delayed

Deep Oesophagus

Scientists, as a group, like to think they behave in ways a little distinct from the herd. The herd, as a herd, likes to think so, too. From time to time, Feedback receives furtive notes from a keen observer of scientists; artful reflections on general behaviours that have caught this person's professional eye. This observer could be described as a "senior figure in the European science community".

In homage to the famous secret source "Deep Throat", this observer will be identified here as "Deep Oesophagus". Here is their first confidential dispatch.

"During the first, especially-confused weeks of the pandemic of 2020, at a research institute that is quite typical in Europe, I saw abundant evidence that the population of approximately a thousand scientists did not differ from the general public in attitude. By 'attitude', I mean: its beliefs and behaviours in regard to the pandemic.

"While 95% of the scientists accepted the general isolation, sanitary and home office measures, the remaining 5% were neatly divided. One half of that 5% announced that full-body protective suits plus asbestos-proof respirators had to be distributed immediately else the four horsemen of the apocalypse would appear next morning on the doorstep. The other half of that 5% announced that the coronavirus was not as contagious as previously assumed, that the mortality rate was marginal, and that the virus anyhow only affected old people over the age of 40. In other words, while the great majority went along with general recommendations and beliefs, there were two approximately equal and oppositely-emphatic fringe groups who disagreed with the majority and with each other.

"The two fringe groups of scientists, in completely disagreeing with each other, both referred to the same peer-reviewed and pre-pub papers."

Deeper secrets

Biological oesophaguses, which connect the throat to the lower portions of the digestive system, sometimes harbour deep secrets. Some of these secrets, in some of these oesophaguses, have religious significance. Here are two of them.

"Esophagus detection using deep learning method", a paper given at a conference in 2021, applies a clever bit of engineering to a meaty problem. One of chicken meat. This problem is longstanding and the study has a new approach to it.

"In order to slaughter a chicken according to the Islamic Law, it is required to sever the trachea, esophagus and both the carotid arteries and jugular veins to accelerate the chicken's bleeding and death. Syariah Compliance Automated Chicken Processing System (SYCUT) uses the Vision Inspection Technology which is built for the purpose of detecting… whether a chicken is halal or not… This paper discusses the possibility of deep learning approach to combat the challenges and its potential for esophagus detection."

"Crucifix foreign body in the middle third of esophagus: A case report", a paper published in 2016, describes a very different problem. The patient, a 46-year-old male, came to the doctors' office in Mexico complaining of a difficulty in swallowing. A CT scan and an endoscope examination detected a metal cross, 5.3 centimetres tall and 3.2cm wide, lodged deep in the oesophagus. The doctors performed surgery, extracting it. The man went home unburdened by the cross and with what the doctors describe as "good oral tolerance". ▮

Marc Abrahams

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70th
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70th anniversary

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